Three essays on agricultural household labor in developing countries

by

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AN ABSTRACT OF A DISSERTATION

submitted in partial fulfillment of the
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DOCTOR OF PHILOSOPHY

Department of Agricultural Economics
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Abstract

Agricultural labor supply in developing countries is an important factor in agricultural productivity and livelihood. Labor productivity, however, is still inefficient due to both internal and external factors. In particular, land markets, credit markets, and social networks are crucial for improving household labor allocation efficiency and, accordingly, agricultural productivity. This dissertation examines the role of gendered land ownership and microcredit on intra- and inter-household labor allocation in Sub-Saharan Africa.

Recent research has increased interest in the intersection of land tenure and gender roles in African agriculture. While formalization of land ownership has been found to have significant impacts in terms of gender, time-use and management remain critical to both the productivity of agricultural operations and the welfare of household members. Thus, it is important to understand how gender intersects with the relationships between the ownership and operation of plots. To address these relationships, in Chapter 1, we used plot-level data from nationally representative household surveys in Ethiopia and Malawi to characterize the ownership structure (e.g., sole male, sole female, or joint) and domain (e.g., plot ownership, plot management, or output management) of control over land in each household.

We then answered the following research questions:

1) Are there any gender gaps in the degrees of the concordance among different domains of controls?

2) How does the structure of ownership and managerial rights affect labor allocations on plots?

We found that for both males and females, sole managerial rights are most likely to occur in plots owned exclusively by either gender. However, on jointly owned plots, instances of sole planting rights are almost exclusively male. We also found that while females supply more of their own labor on plots they control, the pattern of own-gender bias in labor allocation

varies with each structure-domain combination. The heterogeneity of these results suggests gender inequality analyses related to land rights are sensitive to the choice of domain of control.

Chapters 2 and 3 explores the microcredit impacts on inter-household labor sharing in developing countries. Labor sharing in developing countries is related to liquidity constraints, labor deficiency, and seasonality problems. Recent credit policies for the poor in developing countries have significantly increased household livelihood, but there is still ambiguity regarding liquidity effects on shared labor supply. Our research questions were:

1) Does microcredit impact labor sharing arrangements in rural economies?

2) What is the role of network effects on labor sharing groups?

We examined these questions both theoretically and empirically. The theoretical section of Chapter 2 develops a two-period model which includes liquidity constraints. The results of this section show that as the size of the microcredit loan increases, labor sharing and input expenditure also increase. However, family labor supply changes depend on households' preferences regarding leisure, and network effects reduce the effects of microcredit on labor supply and input expenditure. Households with high network effects are less likely to change their shared labor allocation in response to access to larger loans.

In Chapter 3, we used panel data from the Ethiopian Rural Household Survey collected during 1999 to 2009 to answer the above research questions. Three different types of credit services were included in the household fixed effect model as covariates to examine their impact on household labor supply changes over the years. We found that shared labor supply and family labor supply do not change with microcredit loan benefits. These results suggest that liquidity is not the primary reason for households to supply shared labor.

Our results are more consistent with Gilligan (2004) and Mekonnen and Dorfman (2017), who showed that network synergies exist in labor sharing groups. Microcredit loan-takers also purchase more fertilizer, and the effects of microcredit loans on fertilizer expenditure are similar to the effects of fertilizer credit programs. The effects of other credit services on household labor supply are heterogeneous. Village network loan-takers allocate more labor days in labor sharing networks. One possible reason for this is that households are motivated to supply labor in labor sharing networks if they receive credit services from the network. Our results also suggest that social ties and peer pressure encourage network loan-takers to participate in labor sharing groups, whereas fertilizer credit program participants supply less labor in labor sharing networks.

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Dedication

To my God, who made impossible to possible.

Chapter 1

Gender differences in the relationship between land ownership and managerial rights: Implications for intrahousehold farm labor allocation

[1]

1.1 Introduction

Against a backdrop of broad land tenure changes in Sub-Saharan Africa (SSA), international development institutions continue to target reforms that provide women access to ownership and control over land.[2] Many of these reforms focus on formalizing customary or neo-customary tenure systems, which have potentially critical consequences for gender gaps (Boone, 2019). Formalization efforts explicitly focused on promoting legal rights for

[1] A revised version of this chapter was published in *World Development* (https://www.sciencedirect.com/science/article/pii/S0305750X19303171)

[2] In a 2013 report, the United Nations (UN) acknowledged women's land rights as an essential human right necessary to improve the food security and sustainable development (UN, 2013).

women could potentially foster a more gender egalitarian land distribution, while registration processes that disfavor or ignore women's rights may exacerbate existing inequalities.[3] Recent evaluations of tenure system in Ethiopia (Holden et al., 2011), Rwanda (Ali et al., 2014), and Benin (Goldstein et al., 2018) all suggest that basic certification schemes have strengthened the tenure security of women, though productive impacts have been modest.

At the same time, the development of the Women's Empowerment in Agriculture Index suggests renewed attention to female autonomy in agricultural production more broadly. However, despite growing evidence for a strong and positive relationship between women's land right and outcomes like gender equality, consumption and food security (Meinzen-Dick et al., 2019), discussion is lacking on the interface between female land ownership and the gendered distribution of managerial and output rights. These issues are critical for understanding how systematic changes in land tenure are likely to impact key intrahousehold allocative efficiency and productivity challenges that have been a traditional focus of agricultural economists (e.g. Udry (1996)).

In this paper, we investigate the role of gender in the relationship between land ownership and managerial rights, and its implication for intrahousehold farm labor allocation in Ethiopia and Malawi. We have two overarching objectives: a) to characterize the interrelationship of ownership, management and output rights among different genders, and b) to estimate the relationship between the intrahousehold distribution of these rights and the within-household labor allocation to plots.

As Doss et al. (2015) notes, much of the rhetoric on women's land rights lack a basic, descriptive empirical foundation. By pursuing our first objective, with an eye toward elucidating potential gender disparities, we aim to fill the evidence gap on the within household distribution of land rights across different domains of control. With the notable exception of Twyman et al. (2015), who focus on female land ownership and plot management decisions, systematic empirical evidence is lacking on how agricultural land ownership maps to managerial rights, and the extent to which the relationship depends on gender. We aim to

[3] Our focus here is on gender, though Boone (2019) notes the ambiguous effect of land formalization on inequality extends to ethnic and class differences, as well.

fill the gap in the literature by exploring gender differences in the relationship across land ownership and plot managerial rights within households.

Throughout the paper, we focus on three "domains" – plot ownership measured by the right to sell, right to make planting decisions, and right to make decisions on outputs from the plot – and three "structures" of control – male sole, female sole, and joint. We use the term, "domains" of controls, to refer to ownership and managerial rights and the term, "structures" of controls, to refer how ownership and managerial rights are distributed to household members. Using this framework and data from nationally representative household surveys in Ethiopia and Malawi, we address the following research questions: 1) are there any gender gaps in the degrees of the concordance among different domains of controls? and 2) how does the structure of ownership and managerial rights affect labor allocations on plots? Though we find a high degree of gender symmetry in the relationship between land ownership and managerial rights, the evidence suggests that the concept of 'jointness' is not fully egalitarian. On jointly owned plots, female (but not male) sole management over planting is almost non-existent, and joint management is overall more likely to occur on solely female-owned plots relative to solely male-owned plots. We also find that while females supply more of their own labor to plots they control, the pattern of own-gender bias in labor allocation varies with each structure-domain combination.

The remainder of the paper consists of the following sections. First, we describe the literature, highlight our contribution, and provide the institutional background. We then illustrate our dataset and the variables we use and show the patterns of ownership and managerial rights of the plots in our sample across gender followed by the analysis on how the structure of ownership and managerial rights affect labor allocations on plots. We then summarize and discuss our finding and conclude with limitations and suggestions for future research.

1.2 Literature review: Gender, land rights and management and labor allocation

Studies of gender and agricultural labor typically utilize household level information, which neglects within-household plot-level ownership variation. We depart from recent contributions to understanding female land rights - including Doss (2001), Doss et al. (2015), Twyman et al. (2015), De la O Campos et al. (2016), and Wineman and Liverpool-Tasie (2017) - by focusing solely on households with both male and female adults. As a result, our paper is relevant to gender-based issues in agriculture specifically in environments in which women are engaged in joint economic decisions with men. The dynamics governing the *intrahousehold* distribution of land rights and management may be distinct from general patterns. Indeed, if single sex female-headed households are only households that are gaining female control over land, overall national trends could hypothetically indicate positive signals of land egalitarianism even as women living with men are deprived of land.

We also contribute to the literature of intrahousehold farm labor allocation by providing a discussion of the effect of land ownership and managerial rights on intrahousehold farm labor allocation. Previous studies indicate that the assignment of land ownership or managerial rights affects household production (e.g. De la O Campos et al. (2016); Doss (2006); Place (2009); Quisumbing and Maluccio (2003)). Building upon our discussion on how land ownership and managerial rights are gender-specifically interlinked, we provide important findings on how these interlinkages affect intrahousehold farm labor allocation. Labor represents a vitally important input for several reasons; not only is it a key factor of agricultural production, but it also directly affects the welfare of household members and is inextricably linked with issues of autonomy, empowerment, and bargaining power.

Our study also connects to a vast literature on land rights, gender, and the agricultural household.[4] Of particular relevance is recent work that has carefully considered the

[4]Land rights have been examined by number of previous studies to assess the impact of having secure land rights on agricultural investment and thus, productivity (e.g. Besley, T. (1995); Deininger et al. (2017); Dillon and Voena (2018); Goldstein and Udry (2008)). Measures of "land rights" differ among the previous studies: transfer rights (Besley, T., 1995), land title ownership (Goldstein and Udry, 2008), inheritance

importance of different indicators of gender and land ownership. De la O Campos et al. (2016) show that the agricultural productivity gap across gender depends on the choice of the gender indicator on who has the rights to plots, and Doss et al. (2015) and Twyman et al. (2015) emphasize the importance of understanding the meaning of various measures of ownership and control of plots in the context of gender inequality.[5] These studies find that plot ownership by women does not guarantee managerial rights to women. Such findings again highlight the importance of investigating the interlinkage across various measures of ownership and managerial rights. We contribute to the literature by providing empirical evidence on the gender gap in this interlinkage.

The efficiency of intrahousehold labor allocation has been investigated by several previous studies. For example, Udry (1996), Goldstein and Udry (2008) and Andrews, Martyn J. and Golan, Jennifer and Lay, Jann (2014) reject Pareto efficiency within the household, in part due to labor and land market failures. Walther (2018) demonstrates that insecure tenure can cause non-cooperative decision making within the household in Malawi. Although we do not provide an explicit discussion of intrahousehold decision making and Pareto efficiency of labor uses, we contribute to this literature by providing empirical evidence on how ownership and control of plots affect labor use and find suggestive evidence of labor allocation inefficiencies.

1.3 Institutional background

Land tenure institutions vary considerably between different countries, and often within countries (Fenske, 2011). The settings of our study, Ethiopia and Malawi, likewise encompass divergent and diverse land tenure systems. Under a backdrop of increasing land scarcity, Ethiopia and Malawi have developed their own institutions governing land and property rights based on their political and social backgrounds.

In Ethiopia, sweeping land reform in 1975 nationalized land and restricted transac-

rights (Dillon and Voena, 2018), and land market participation (Deininger et al., 2017).

[5]Similarly, Peterman et al. (2015) and Seymour and Peterman (2018) show that common indicators of gender and household decision making are sensitive to aggregation and construction differences and their interpretation is highly context dependent.

tions (Holden and Otsuka, 2014). The reforms restricted farmers to usufructuary rights, and converted large swaths of commercial farms to egalitarian smallholders (Kebede, 2008). The 1995 Federal Constitution affirms that land is owned by the State while farmers have right to inherit their land only to their family. Although a 2005 proclamation eased the restriction on land rentals, land still cannot be formally transacted (Deininger et al., 2008; Kosec et al., 2017; Tigistu, 2011). Nevertheless, land can be bequeathed to others, and the regulation of transactions differs by region. Thus, a substantial portion of farmers reports sales rights on their land.

Deininger et al. (2017) describe Malawi's land tenure system as "dualistic": smallholders farm food crops in a customary system traditionally characterized by egalitarian access and diverse inheritance systems, while commercial crops (usually tobacco) are farmed in a formal, private system. [6] Faced with increasing land scarcity and conflict, land tenure reform has become a perennial public policy issue in Malawi. While a National Land Policy proposal has existed for over a decade, implementation of national reforms has been slow.

Considerable variability exists within customary land tenure systems in Malawi, particularly in relation to matrilineal versus patrilineal inheritance, as well as land transaction practices (Berge, Erling and Kambewa, Daimon and Munthali, Alister and Wiig, Henrik, 2014; Holden et al., 2006). However, despite these differences, land transactions appear to have been increasing since the 1990s (Peters and Kambewa, 2007). These transactions are not explicitly state-sanctioned, but have evolved such that "customary land continues to be regarded as a resource with use but *also exchange values*" (Jimu (2012); emphasis added). Thus, sales rights are a meaningful measure of land ownership, though security of tenure remains a significant concern for many smallholders (Deininger et al., 2017).

[6]Private land is distributed between freehold and 'estate' or converted customary land. Jere (2012) estimates that as of 1998, customary land comprised 65 percent of total land area in Malawi.

1.4 Data and descriptive statistics

We use nationally representative survey data from the World Bank's Living Standard Measurement Study - Integrated Survey on Agriculture (LSMS-ISA) program. We combine data from two recent rounds of household surveys in Ethiopia and Malawi, which are 2013 – 2014 and 2015 – 2016 Ethiopia Rural Socioeconomic Surveys, 2013 Malawi Integrated Household Panel Survey and 2016 – 2017 Malawi Fourth Integrated Household Survey. We use the two recent rounds because they include questions that consistently measure the ownership and managerial rights of surveyed plots.[7]

The LSMS-ISA program supports Sub-Saharan African countries to implement nationally representative household surveys with a focus on agriculture. Typically, these surveys collect data on the demographics, education, health, and employment of households, as well as plot-level information on input use, cultivation, production, and the identity of managers and owners (Palacios-Lopez et al., 2017).

Since our objective is to understand intrahousehold dynamics of farm ownership, managerial rights and labor allocation, we restrict our sample to the cultivated plots (fields) in households with at least one adult male and one adult female. Accordingly, female-headed households with no adult male between 15-64 years old or male-headed households with no adult female are excluded in our analysis. We also restrict our sample to plots where each domain of controls is assigned to at least one individual in the household. Consequently, we exclude 38.98% and 58.73% of the cultivated plots from Ethiopia and Malawi.

Ownership of a plot can be defined in several ways (De Janvry et al., 2015; Doss et al., 2015; Fenske, 2011). In the household surveys we use, there are questions distinguishing the identity of the holder of the plot, the title-holder of the plot, and who has the right to sell the plot. Since the definition of *holder* may be subjective, and the meaning of plot certification may be ambiguous, we identify the plot owner based on the response to the question, "who has the right to sell the plot?".[8] This is similar to Besley, T. (1995) where the self-reported

[7] We choose to use the most recent two rounds from each country to maximize statistical power and capture recent social and economic phenomena. Unfortunately, other waves do not contain sufficient information on the variables required for our analysis.

[8] A possible alternative is to use "documented ownership (title-holder)". However, we believe that using

transfer rights are used as the key measure of land rights. While the right to alienate land may be distinct from ownership, it consistently identifies the individual with the most senior or exclusive exchange value right to the land.[9]

Table 1.1 reports the shares of the cultivated plots by structure and by domain of controls. We focus on three structures—male sole, female sole, and joint—and three domains— rights to sell, rights on planting decision, and rights on output. Table 1.1 shows that about three-fourth of plots in Ethiopia are jointly owned and jointly managed for planting decisions. The share of the plots with outputs jointly managed is above 80%. Within the plots with sole control by one household member, the shares of male sole and female sole are similar for the output management domain, but the share of male sole is greater for the other two domains. In Malawi, the share of plots that are solely owned is much higher than Ethiopia. Similar to Ethiopia, managerial rights are likely to be shared between males and females. However, there is no gender gap in sole ownership or management in Malawi.

Table 1.2 reports descriptive statistics of the key variables we utilize to explain intra-household dynamics of land ownership, managerial rights and labor inputs. Except the labor days variables, these are the control variables that we include in the regression equations in the later sections. Household characteristics are similar across different ownership domains except the gender of the household head. As expected, we observe that sole ownership of females occur more often in female-headed households. The proportion of the female-solely-owned plots from female-headed households is higher in Ethiopia compared to Malawi.

Plot-level variables are more heterogeneous across the different structures of ownership and vary across countries. In general, plot sizes are smaller in Ethiopia than Malawi. In Ethiopia, plot sizes are relatively similar across male-owned, female-owned, and jointly owned

this variable is less practical in our context since only 3% of the plots in Malawi data are certified and have information on who is the title-holder.

[9] Our definition is not intended to suggest the concept of ownership cannot exist without alienation, but to focus on a well-defined sample of plots with a clear criterion for ownership. Because we exclude plots where no household member has a sale right - either solely or jointly - we do not consider plots in which households have embedded ownership rights while alienation rights are vested exclusively with a community or political institution. Such arrangements can occur in customary tenure systems, in particular.

plots. In Malawi, female-owned plots are about 35% smaller than other plots.

Notable differences in agricultural inputs emerge across ownership structures. The amount of inorganic fertilizer used in female-owned plots is smaller than other plots, though per acre rates are similar in Malawi. The patterns in labor inputs are less clear. Male labor days are lower in female-owned plots but female labor and labor from other family member are greater in female-owned. In section 1.5, we systematically investigate labor allocation across structures and domains of control in the sample plots.

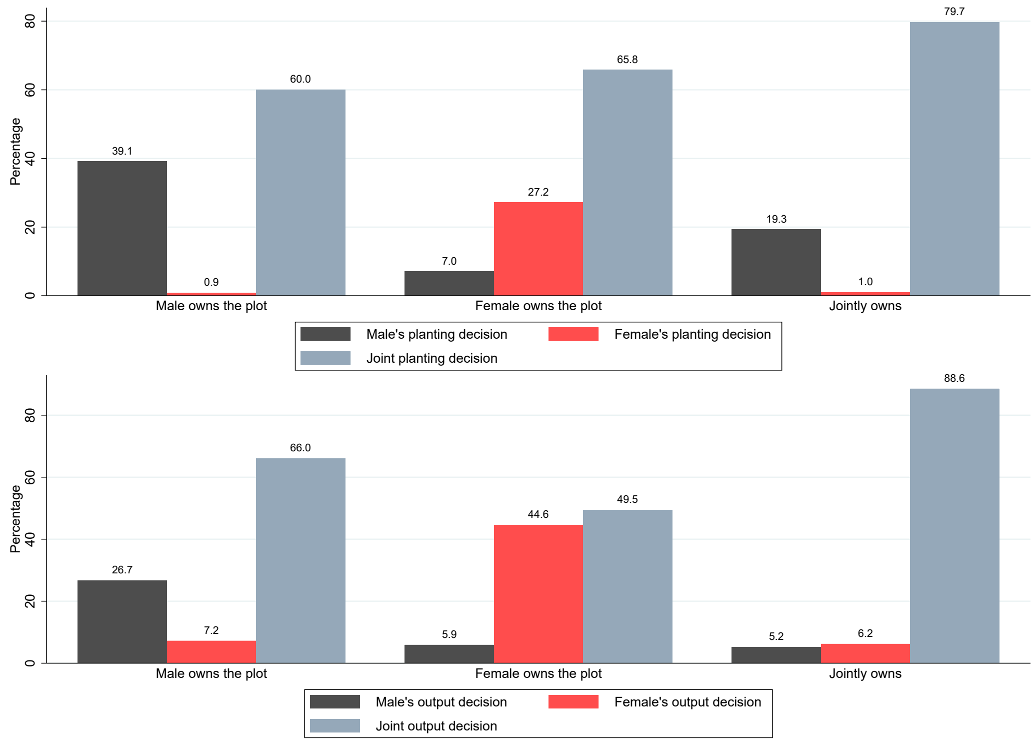
1.5 The relationship between land ownership and managerial rights

We first explore how the different structures - male sole, female sole, and joint - and domains of controls - rights to sell, rights to make planting decisions, and rights on outputs - are correlated with each other. Our objective in this section is to explore whether having ownership of a plot leads to other managerial rights (i.e. planting or output control) and whether gender differences arise in the relationship between ownership and managerial rights.

Figure 1.1 presents the shares of plots with gender-specific managerial rights by ownership structure. While high shares of joint management are present, we observe gender-specific concordance for both managerial rights and differences in the degrees of gender-specific concordance between males and females across the two managerial right domains. In nearly every male owned plot, either the male makes the planting decision (39%) or it is joint (60%). In female owned plots, female sole management over planting is prevalent (27%), but not to the same extent as for males. In jointly owned plots, joint management of planting predominates (80%), but sole management on these plots is not egalitarian. Male sole management occurs in 19% of jointly owned plots, though female ownership is almost non-existent, with the gender gap driven by observations from Ethiopia (see Table 1.4).

Overall, females have substantially more sole decision making around outputs than for planting across all structures of control. In fact, females are more likely to solely manage outputs on female-owned plots than males on male-owned plots. Similar patterns arise in the shares of the plots in each domain-by-structure combination, which we present in the appendix.

Figure 1.1: *Percentage of plots with gender-specific managerial rights by ownership structure*



Source: World Bank LSMS–ISA

We formally assess the correlation across ownership and the two managerial rights with regression analyses. For plot j, in household k, in round t, we estimate the following equation:

$$DM_{jkt} = \alpha_0 + \alpha_1 F_{jkt} + \alpha_2 J_{jkt} + \Gamma X_{jkt} + u_k + v_t + \epsilon_{jkt} \quad (1.1)$$

where DM_{jkt} is the indicator variable for various structures and managerial rights combinations. The indicator variable, F_{jkt}, indicates whether female has the sole right to sell plot j or not, J_{jkt} indicates whether plot j is jointly owned or not, X_{jkt} is a vector of plot and household characteristics and u_k and v_t are households and rounds fixed effects.[10] We

[10]The omitted variable bias occurs when a) we leave out relevant explanatory variables that affect the

separately estimate six equations with six different dependent variables: female solely, male solely, and joint planting decisions, and male's sole right, female's sole right and joint right on outputs. To incorporate fixed effects, we use a linear probability model for equation (1.1).[11] Table 1.3 reports the estimation results. The first three columns report results for the equations in which the dependent variable refers to planting decisions, and the next three columns report estimates of the rights to manage outputs. As expected, we observe strong degrees of gender-specific concordance. Female-owned plots are much more likely to be managed by females compared to jointly owned plots. In columns (1) and (4), we find that the coefficients of the female sole ownership variable are positive and statistically significant whereas the coefficients of the joint ownership variable are either insignificant or negative. We reject both the null hypotheses, $\alpha_{11} - \alpha_{21} = 0$ and $\alpha_{14} - \alpha_{24} = 0$, which we report in the table 1.4. This indicates that the likelihood that a plot is solely managed by a female is statistically larger in female-owned plots compared to jointly owned plots. Similarly, male-owned plots are more likely to be managed by males compared to jointly owned plots (i.e. the negatives of α_{23} and α_{26} are positive and significant).

We test whether these gender-specific concordances are stronger for males than females by re-estimating the six equations jointly within a Seemingly Unrelated Regression (SUR) framework and conducting cross-equation hypothesis tests. Specifically, we test the null hypotheses that $(-\alpha_{22}) - (\alpha_{11} - \alpha_{21}) = 0$ and $(-\alpha_{25}) - (\alpha_{14} - \alpha_{24}) = 0$. These test that the likelihood of a male-owned plot being managed by males and the likelihood of a female-

dependent variable, and b) the left-out explanatory variables are correlated with the key explanatory variables and thus, our concern is leaving out the variables that satisfy the both conditions. We suspect that household characteristics such as the characteristics of the head of the household and accessibility would affect both who is the owner and who manages for the plots we are analyzing, and other time-invariant household characteristics are captured by the household fixed effects. We believe that plot characteristics such as input uses and crop choices have similar concerns and thus include them in the regressions.

[11] Since the dependent variables are binary variables, one can argue that it is important to incorporate the nonlinearity and models such as Logit or Probit are more appropriate. However, in such models, incorporating fixed effects leads to inconsistency of the estimates (i.e. incidental parameter problem) and obtaining proper standard errors is also challenging. While we keep the linear probability model as our main specification, we provide the results from Probit model with correlated random effects and conditional Logit fixed effects model in the online appendix. The Probit correlated random effects model and conditional Logit fixed effects model are alternative ways to control for unobservable time-invariant household-level heterogeneity (Frederiksen et al., 2007; Magnac, 2004; Wooldridge, 2010). The results remain robust in general.

owned plots being managed by females—relative to jointly owned plots—is equal. Although the relative magnitudes are larger for male-owned plots, we fail to reject the null hypothesis for both planting and output management (see table 1.4).

There are also similarities across gender in the relative distribution of sole rights on non-concordant plots. The likelihood that females (males) engage in sole management decisions on plots owned by males (females) is similar to the likelihood on jointly owned plots. The coefficients α_{21} and α_{24} are statistically insignificant, indicating that sole female planting and output decision in jointly owned plots are statistically indistinguishable compared to those for male-owned plots. We execute a similar test for males. In column (2), we find that the coefficient of the female ownership variable (α_{12}) is more negative than the coefficient of the joint ownership variable (α_{22}), but we fail to reject the null hypothesis, $\alpha_{12} - \alpha_{22} = 0$. Thus, the likelihood of a plot to be solely managed by males is statistically indistinguishable in jointly owned plots versus female-owned plots. The likelihoods of males having sole rights on outputs between female-owned and jointly owned plots is even closer in magnitude, and we fail to reject the null hypothesis, $\alpha_{15} - \alpha_{25} = 0$ (see table 1.4 for the hypothesis testing results).

Despite these similarities across genders, we find suggestive evidence that female-owned plots are more likely to be jointly managed compared to male-owned plots. The coefficients for both planting decisions (α_{13}) and output decision (α_{16}) are positive, though the former is marginally insignificant and the latter significant only at the 10 percent level. Though imprecise, the direction of the estimates indicates that men are more likely to join in the managerial decisions in female-owned plots than women are to participate in such decisions in male-owned plots.

Overall, we find strong evidence of gender-specific concordance across different domains of control. Despite a high degree of symmetry between males and females in the relative concordance levels, our findings hint at a gender gap in the concept of "jointness". Joint management is more commonly associated with female-owned plots than male-owned plots, and instances of sole planting rights on jointly-owned plots are almost exclusively male. While the patterns are in general similar across the two countries, we do see a notable difference in how land ownership maps to joint output rights. In Ethiopia, male-owned plots are significantly less likely to have joint output rights, but in Malawi we find no statistical differences in their occurrence across male, female and jointly owned plots (Appendix tables A.4 and A.5).

1.6 The relationship between the gender structure of control over land and labor allocation

In this section, we explore how each domain-by-structure combination is correlated with the labor input of the primary adult male, female, other household members and hired labors. Particularly, we focus on investigating the presence of gender-specific concordances in labor allocations and whether the degree of the concordance differs between males and females.[12]

Figure 1.2 shows the distribution of male and female labor inputs across plots with different domains and structures of controls. Gender-specific concordances are reflected in both male and female labor distributions in all domains. In both male and female labor distributions, we observe greater densities around zero in plots owned or managed by their opposite gender and greater densities around positive values in plots owned or managed by themselves. We also see that both male and female labor follow similar distributions in male-controlled or jointly-controlled plots. That suggests that the concept of "jointness" is closer to male-control than female-control in the context of labor allocations.

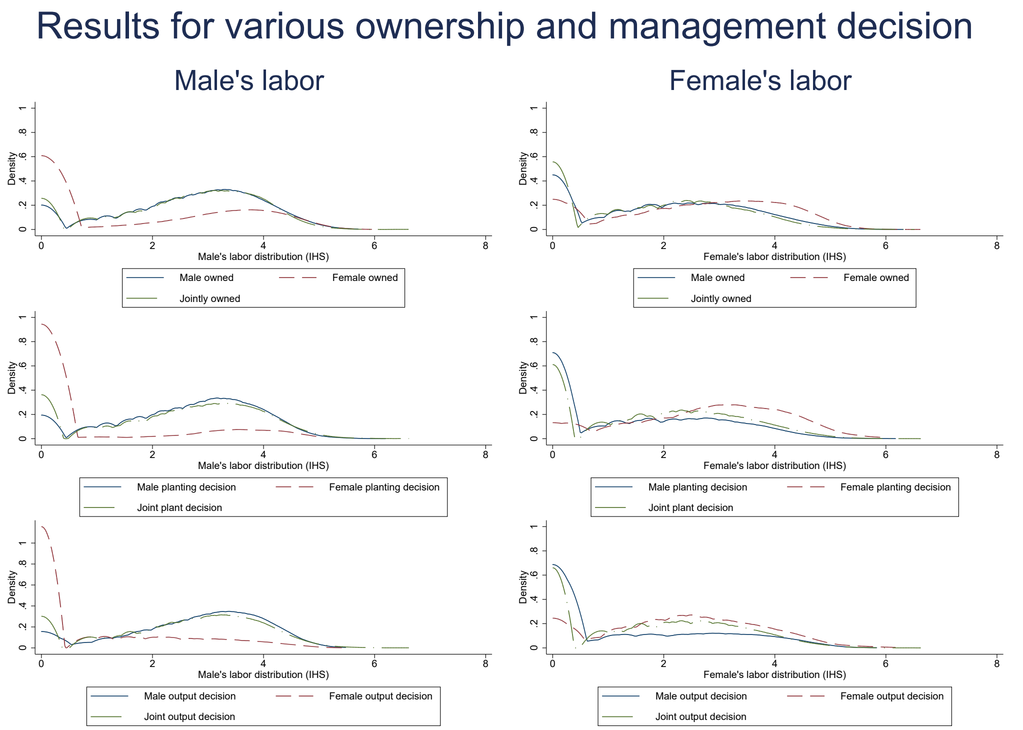
Similar to the previous section, we formally assess the gender-specific concordance in labor allocation by estimating the following equation:

$$Y^i_{jkt} = \beta^i_0 + \beta^i_1 FS_{jkt} + \beta^i_2 FP_{jkt} + \beta^i_3 FO_{jkt} + \beta^i_4 JS_{jkt} + \beta^i_5 JP_{jkt} + \beta^i_6 JO_{jkt} + \Gamma^i X_{jkt} + u^i_k + \theta^i_t + \epsilon^i_{jkt} \quad (1.2)$$

For each of the four categories of labor, primary adult male, female, other household

[12] Unlike Palacios-Lopez et al. (2017), our analysis focuses on plot level, as opposed to household level, relationships between gendered labor allocation and land ownership.

Figure 1.2: *Labor distributions by domain and structure of controls*



Source: World Bank LSMS–ISA
Note: In each domain of control, the density of the inverse hyperbolic sin (IHS) of either male or female labor is plotted for each structure of control subsample.

members, and hired, Y^i_{jkt} represents labor days provided in plot j in household k in time t. Accordingly, $i = m, f, o, h$ which indicates male, female, other household members, and hired persons. For each domain of control (ownership, planting, output), a plot is categorized as under female control, joint control, or male control. Accordingly, female and joint ownerships are denoted by the dummy variables FS_{jkt}, and JS_{jkt}, female planting decision and joint planting decision are denoted by FP_{jkt} and JP_{jkt}, and female output decision and joint output decision are denoted by FO_{jkt} and JO_{jkt}. Male sole control is the omitted category. The vector, X_{jkt}, consists of the control variables listed in Table 2.[13]

Household fixed effects are denoted by u^i_k, which controls for time invariant household characteristics that might impact labor allocation. Because plots cannot be tracked across rounds, the parameters are identified by within household variation both across and between

[13]Similar to equation (1.1), we include the household and plot characteristics and the household and round fixed effects to mitigate potential omitted variable bias.

rounds. We also include a time fixed effect θ_t^i to control for generic differences between rounds. We jointly estimate four labor allocation equations (male, female, other household member, and hired labor equations) via Seemingly Unrelated Regression (SUR) to control for possible correlation in error terms across equations.

In Table 1.5, we report the estimation results on the relationship between labor allocation and domains and structures of controls of the plots. Columns (1) through (4) are estimated using the pooled sample and columns (5) through (12) reports the results from country-specific regressions. In every specification, the estimated coefficients of our variables of interest should be interpreted relative to the omitted group of sole male control. We also provide various within equation hypothesis testing results in the table 1.7.

First, every domain of control exhibits some degree of gender-specific concordance in the relationship between labor allocation and the structure of control. Females supply more labor to plots on which they have a sole right to sell, a sole right to make planting decisions, and a sole right on outputs (β_1^f, β_2^f, and β_3^f). On female-controlled plots, males generally supply less labor (β_2^m and β_3^m). While the general direction remains consistent across the pooled sample, Ethiopia, and Malawi, the pattern is less strong in Malawi. In that country, only female sole right to make planting decisions has a statically significant effect on labor (negative for male labor days and positive for female labor days).

Second, the magnitude of the gender-specific concordance varies across the domain of control. Own-gender effects on labor are greater for managerial rights than for ownership. Specifically, in the pooled sample, output decisions have the highest own-labor effects, with females supplying 78 percent more labor on plots where they solely control the output decisions, relative to plots where males solely control the output. For planting decisions, the same effect is less than half (40 percent). Sole female control of the right to sell a plot has the smallest impact on relative female labor supply, with an increase of just 18 percent over sole male control (not significant at the five percent level). The relative reduction in male labor on solely female controlled plots is also largest for the output decision domain (-80 percent), followed by planting decisions (-52 percent). For the right-to-sell domain, the coefficient is small and not significant. The same pattern also appears in the Ethiopia-only sample, though for Malawi, as described above, the coefficients are only significant for the female sole right to make planting decisions.

Third, jointly controlled domains (β_4^i, β_5^i, and β_6^i) do not have the same relationship with labor allocation as either solely female or male-controlled domains and the relationship also differs across countries. In the pooled and Ethiopia samples, we find greater labor allocations of male, female, and other household members and less hired labor in jointly owned plots compared to those in male owned plots. We also observe less male labor in plots with joint planting decisions compared to those with a male sole planting right and greater labor allocations from female and other household members in plots with joint output decisions compared to those with the male sole output rights. In Malawi, the only statistically significant jointly controlled domain is the right to make planting decisions, which is associated with higher female labor.

Finally, plots where women have either the sole right to sell or sole control over output are supplied with less hired labor in Ethiopia. Relative to plots where men have sole control over sales, when women have sole land sale control there are 9 percent fewer hired labor days. For sole female output decisions, there are 27 percent less hired labor days, while for sole female planting decisions the relationship is null. Thus, even though sales rights have the weakest correlation with the gendered allocation of household labor, hired labor input use remains significantly reduced for sole female control of this domain. We also observe that hired labor in female-controlled plots is either statistically not different from those in jointly controlled plots or lower (Within equations test results (3) in table 1.7). In the Malawi-only sample, hired labor inputs was not statistically linked to the domain or structure of plot control.

Table 1.6 presents cross-equation hypothesis testing results. Utilizing the SUR estimation, we test whether the degrees of gender-specific concordances are stronger in male-controlled domains compared to female-controlled domains. The first set of hypotheses in table 1.6 tests whether the degree of gender concordance is equal between for males or females (i.e. effect of male control on male labor vs. female control on female labor). In all domains for the pooled sample and the Ethiopia-only sample, we reject the null of equality and find that the degree of gender-specific concordance is greater in female-controlled plots. For the Malawi-only sample, we only reject the null for the planting decision domain.

1.7 Summary of empirical findings and discussion

In this paper, we explore the role of gender in the relationship between land ownership and managerial rights, and its implication for intrahousehold farm labor allocation. We find that both females and males are more likely to report control over the management of plots on which they claim exclusive transaction rights. We also find suggestive evidence of disadvantages faced by women in the concept of 'jointness', both in terms of joint management and joint ownership. The former is more likely to occur on solely female owned plots than male owned plots, and the latter is more likely to entail male sole planting decisions than female sole planting decisions.

The empirical patterns derived from the analysis of labor allocation suggest several important implications. First, our finding on the gender-specific concordance in the relationship between labor allocation and the structure of control is consistent with previous studies that document intrahousehold inefficiencies in agricultural investment.[14] For the patterns observed here to derive from an efficient allocation of labor, there would need to be a fairly distinct form of sex-disaggregated comparative advantage for management and labor activities.

Second, the fact that labor allocations patterns differ across domains of land control suggests that the choice of variable in defining gendered control over agricultural activity is likely important when analyzing production and input use questions. The sensitivity of our results to the precise domain (land sales, planting, output) echoes not only De la O Campos et al. (2016), who find similar sensitivity in analyzing productivity in Uganda, but also several other studies, such as Peterman et al. (2015) and Seymour and Peterman (2018), which find that measures of women's bargaining power are dependent on how common decision-making questions are constructed, aggregated and interpreted.

[14]This literature has a long tradition since Udry (1996).

By implication, research on the relationship between plot ownership, gender and agricultural labor may not generalize across different definitions of "ownership". Andrews, Martyn J. and Golan, Jennifer and Lay, Jann (2014), for example, demonstrate intrahousehold inefficiencies in labor allocations between plots and crops in Uganda, though that finding may be an artifact of defining plot ownership based on output control. Not only do we find that the labor allocations are sensitive to the precise domain, but we also find the linkage across different domains is heterogenous between males and females.

Third, the weaker gender pattern in labor allocation on joint plots is consistent with other studies suggesting such plots do not suffer from the same incentive problems facing plots under the control of a single household member (Andrews, Martyn J. and Golan, Jennifer and Lay, Jann, 2014; Kazianga and Wahhaj, 2013).

Finally, in both Malawi and Ethiopia, the gender balance of labor followed the gender identity of management rights more strongly than ownership rights. However, in Ethiopia, the gender of the output decision maker matters most for labor allocation, while in Malawi it is the gender of the planting decision maker. If the compensation for agricultural labor is embedded in realizing the gains from output, the pattern in Ethiopia may simply reflect the implied incentive structure. Household members work relatively more on plots where they can control the output and enjoy the returns on production. The difference in Malawi may owe to the presence of tobacco, whose labor requirements are four times greater than maize, the most common alternative (Negri and Porto, 2016). In our data, the results similarly suggest that in Malawi, but not Ethiopia, cereal cultivation is associated with significantly less labor use. As a consequence of the greater labor variability of crop choice in Malawi, planting decision power may be more closely tied to labor allocation.

1.8 Concluding remarks

Our empirical findings suggest that control over the various domains of agricultural production influence labor use on corresponding plots. However, an alternative possibility is that the responses to questions of land control are themselves endogenous to labor supply. If that is the case, the implied direction of causality is reversed: the assignment of 'control' over a given plot is determined by the ultimate labor allocation outcome.

The possibility of reverse causality in the relationship between labor allocation by gender and the structure of control is supported by the pattern of results across domains. Own-gender effects are strongest for measures of managerial control—output and planting decisions—and weakest for measures of ownership (i.e. right to sell). Because the right to sell land requires sanction external to the household, it is least susceptible to this form of reporting endogeneity. On the other hand, managerial decisions are fully determined within the household, and therefore most able to endogenously respond to labor allocation outcomes. That codetermination may be particularly acute for households where some members migrate, as even temporary relocations represent allocation decisions of both labor and managerial rights by default. The high correlation we find between reports of female managerial input and female labor provision on a given plot are consistent with the findings of Twyman et al. (2015) in a very different context, Ecuador, which further suggests the possibility of a persistent pattern in survey response. If managerial responses are indeed endogenous, they call into question studies that rely on such demarcations for efficiency tests. Disentangling the direction of the causality is difficult, but one potential avenue is to collect both pre and post cropping season data on domains of control paired with an exogenous shock to labor allocation. Future progress in understanding and improving these measures would be a crucial contribution to the literature on gender and agriculture.

Table 1.1: *Shares of cultivated plots by structure and domain of controls*

Ethiopia (n=27,322)	Male only	Female only	Joint
Right to sell (%)	16.94	7.9	75.16
Plant decision (%)	22.49	2.77	74.75
Output decision (%)	8.58	9.73	81.7
Malawi (n=2,276)	Male only	Female only	Joint
Right to sell (%)	38.09	38.18	23.73
Plant decision (%)	11.95	12.92	75.13
Output decision (%)	18.32	17.31	64.37

Sources: World Bank Living Standard Measurement Survey (LSMS) – Integrated Survey on Agriculture (ISA)
Notes: Each row sums up to 100%.

Table 1.2: *Descriptive statistics of key variables by ownership structure*

	Ethiopia (n=27,322)			Malawi (n=2,276)		
Ownership structure	Male only	Female only	Joint	Male only	Female only	Joint
Household characteristics						
Head is female (yes=1, no=0)	0.02	0.75	0.06	0.01	0.29	0.14
	(0.136)	(0.432)	(0.233)	(0.117)	(0.456)	(0.344)
Head's age	45.62	49.97	46.67	43.26	43.66	44.66
	(13.577)	(11.523)	(12.648)	(12.506)	(12.517)	(12.204)
Head's education level	2.00	0.89	2.04	7.18	6.99	7.09
	(3.159)	(2.371)	(3.098)	(3.280)	(3.717)	(3.506)
Reside in rural (yes=1, no=0)	0.99	0.96	0.97	0.94	0.88	0.93
	(0.121)	(0.205)	(0.158)	(0.233)	(0.322)	(0.256)
Distance to road (km)	13.86	12.81	14.00	9.91	9.61	9.22
	(15.184)	(14.173)	(14.603)	(10.127)	(10.107)	(9.815)
Plot characteristics						
Plot size (acre)	0.346	0.386	0.441	1.417	0.887	1.427
	(0.833)	(2.652)	(2.551)	(3.938)	(0.789)	(1.960)
Grow only cereals (yes=1, no=0)	0.486	0.459	0.477	0.439	0.369	0.430
	(0.500)	(0.498)	(0.499)	(0.497)	(0.483)	(0.495)
Use organic fertilizer (%)	0.315	0.348	0.336	0.143	0.234	0.157
	(0.464)	(0.476)	(0.473)	(0.350)	(0.423)	(0.365)
Inorganic fertilizer use (kg)	9.268	8.619	20.905	63.302	37.964	44.074
	(139.20)	(87.275)	(263.03)	(306.13)	(69.249)	(61.284)
Average male's labor days	12.494	2.899	12.186	26.932	19.319	24.222
	(17.095)	(11.611)	(17.547)	(21.315)	(20.716)	(20.310)
Average female's labor days	4.726	7.611	5.989	27.253	28.965	28.172
	(9.821)	(12.247)	(12.328)	(21.993)	(24.951)	(21.974)
Other household member's labor days	6.096	13.255	7.312	19.141	20.918	23.678
	(12.919)	(19.248)	(15.569)	(28.977)	(29.154)	(29.545)
Hired labor days	1.793	1.696	1.561	3.541	3.207	3.243
	(6.792)	(5.033)	(7.414)	(9.084)	(7.881)	(7.831)
Number of observations	4,628	2,158	20,536	867	869	540

Sources: World Bank Living Standard Measurement Survey (LSMS) – Integrated Survey on Agriculture (ISA)
Notes: Notes: Standard deviations are in parentheses. Ownership is determined by the household member identified as having the right to sell the given plot. All plots with no ownership, no planting decision maker or no output decision maker from the household are excluded.

Table 1.3: *Likelihood of ownership leading to managerial rights*

	(1) Female's planting decision	(2) Male's planting decision	(3) Joint planting decision	(4) Female's right on outputs	(5) Male's right on outputs	(6) Joint right on outputs
Female solely has right to sell (α_{1i})	0.048	-0.130	0.081	0.084	-0.156	0.072
	(0.023)**	(0.045)***	(0.050)	(0.028)***	(0.028)***	(0.039)*
Joint right to sell (α_{2i})	0.002	-0.095	0.093	-0.012	-0.155	0.167
	(0.003)	(0.034)***	(0.034)***	(0.009)	(0.022)***	(0.024)***
Head is female (Γ_1)	0.252	-0.243	-0.009	0.333	-0.052	-0.281
	(0.068)***	(0.076)***	(0.106)	(0.077)***	(0.042)	(0.073)***
Head's age (Γ_2)	0.000	0.000	-0.000	-0.000	0.003	-0.003
	(0.001)	(0.003)	(0.003)	(0.001)	(0.002)	(0.003)
Head's education years (Γ_3)	0.003	-0.011	0.007	0.004	-0.001	-0.003
	(0.002)	(0.008)	(0.009)	(0.003)	(0.005)	(0.006)
Plot size(acre) (Γ_4)	-0.000	0.000	-0.000	-0.005	0.002	0.003
	(0.000)	(0.003)	(0.003)	(0.001)***	(0.001)	(0.001)**
Plot size sq. (acre) (Γ_5)	0.000	-0.000	0.000	0.000	-0.000	-0.000
	(0.000)	(0.000)	(0.000)	(0.000)***	(0.000)	(0.000)**
Cultivate cereals only (Γ_6)	-0.003	-0.005	0.008	-0.044	0.008	0.036
	(0.001)***	(0.004)	(0.004)**	(0.004)***	(0.003)**	(0.004)***
Organic fertilizer usage (Γ_7)	0.004	-0.019	0.015	0.043	-0.023	-0.020
	(0.003)	(0.007)***	(0.007)**	(0.005)***	(0.005)***	(0.006)***
Fertilizer use (100 kg) (Γ_8)	0.000	0.002	-0.003	-0.003	0.002	0.000
	(0.000)	(0.001)	(0.001)*	(0.001)***	(0.001)	(0.002)
Distance to road(km) (Γ_9)	0.018	-0.113	0.095	0.020	-0.011	-0.009
	(0.020)	(0.064)*	(0.068)	(0.030)	(0.025)	(0.039)
F-statistic	2.60***	3.42***	1.98**	19.66***	7.28***	13.28***
N	29,598	29,598	29,598	29,598	29,598	29,598

Note: *** p< 0.01 ** p< 0.05 * p<0.10.
All six equations are estimated with household and round fixed effects.
Note that subscript i in coefficient α_{1i} and α_{2i} indicates column number where $i = 1, \ldots, 6$.
Standard errors are clustered at household level.

Table 1.4: *Within- and cross-equation restriction test results*

Hypothesis	Description of Null Hypothesis	Results	Decision
Within-equation restrictions			
(1) $\alpha_{11} - \alpha_{21} = 0$	Female's likelihood of managing the plot for "planting" decision in female's sole owned plot and jointly owned plot are identical.	0.046 (0.023)**	Reject
(2) $\alpha_{14} - \alpha_{24} = 0$	Female's likelihood of managing the plot for "output" decision in female's sole owned plot and jointly owned plot are identical.	0.096 (0.029)***	Reject
(3) $\alpha_{12} - \alpha_{22} = 0$	Male's likelihood of managing the plot for "planting" decision in female owned plot and jointly owned plot are identical.	-0.035 (0.036)	Fail to reject
(4) $\alpha_{15} - \alpha_{25} = 0$	Male's likelihood of managing the plot for "output" decision in female owned plot and jointly owned plot are identical.	-0.001 (0.021)	Fail to reject
(5) $\alpha_{13} - \alpha_{23} = 0$	The likelihood of the joint management for "planting" decision in female's sole owned plot and jointly owned plot are identical.	-0.011 (0.432)	Fail to reject
(6) $\alpha_{16} - \alpha_{26} = 0$	The likelihood of the joint management for "output" decision in female's sole owned plot and jointly owned plot are identical.	-0.095 (0.034)***	Reject
Cross-equation restrictions			
(7) $\alpha_{11} - \alpha_{13} = 0$	Female's likelihood to manage the plot for "planting" decision and the likelihood of jointly managing the plot for "planting" decision in female owned plot are identical.	-0.033 (0.063)	Fail to reject
(8) $\alpha_{14} - \alpha_{16} = 0$	Female's likelihood to manage the plot for "output" decision and the likelihood of jointly managing the plot for "output" decision in female owned plot are identical.	0.012 (0.062)	Fail to reject
(9) $(-\alpha_{22}) - (\alpha_{11} - \alpha_{21})$	Relative to jointly owned plot, male's planting decision making power over male owned plot and female's planting decision making power over female owned plot are identical.	0.048 (0.041)	Fail to reject
(10) $(-\alpha_{22}) - (\alpha_{11} - \alpha_{21})$	Relative to jointly owned plot, male's output decision making power over male owned plot and female's output decision making power over female owned plot are identical.	0.059 (0.036)	Fail to reject
(11) $(-\alpha_{22}) - (\alpha_{11} - \alpha_{21}) -$ $(-\alpha_{22}) - (\alpha_{11} - \alpha_{21})$	The difference between concordance for "planting" decision and "output" decision is identical.	-0.011 (0.053)	Fail to reject

Note: *** p<0.01 ** p< 0.05 * p<0.10. The coefficient α_{11},α_{12} and α_{13} are planting decision of female, male, and joint with respect to female's sole plot ownership. Likewise, α_{14},α_{15} andα_{16} are coefficients of the output decision right of female, male, and joint with respect to female's sole plot ownership. α_{21},α_{22}, α_{23}, α_{24}, α_{25} and α_{26} are coefficients of female's planting, male's planting, joint planting, female's output, male's output, and joint output decision with respect to joint plot ownership.

Table 1.5: *The influence of structure and domain of control on plot level labor inputs*

	Pooled sample				Ethiopia only				Malawi only			
	(1) Male's labor days	(2) Female's labor days	(3) Other HH labor days	(4) Hired labor days	(5) Male's labor days	(6) Female's labor days	(7) Other HH labor days	(8) Hired labor days	(9) Male's labor days	(10) Female's labor days	(11) Other HH labor days	(12) Hired labor days
Head is female	-1.209	-0.175	0.152	0.066	-1.514	-0.165	0.089	-0.062	-0.451	-0.056	0.154	0.461
(Γ_1^i)	(0.253)***	(0.185)	(0.205)	(0.105)	(0.284)***	(0.230)	(0.215)	(0.121)	(0.370)	(0.245)	(0.547)	(0.220)**
Head's age	-0.016	-0.003	0.018	-0.007	-0.020	-0.002	0.014	-0.009	0.013	-0.008	0.056	-0.007
(Γ_2^i)	(0.005)***	(0.005)	(0.007)***	(0.005)	(0.005)***	(0.005)	(0.007)**	(0.005)*	(0.013)	(0.009)	(0.017)***	(0.010)
Head's education years	-0.007	-0.036	-0.033	-0.002	-0.005	-0.040	-0.034	-0.019	-0.039	-0.013	-0.026	0.034
(Γ_3^i)	(0.012)	(0.014)***	(0.019)*	(0.011)	(0.014)	(0.017)**	(0.021)	(0.012)	(0.020)**	(0.016)	(0.038)	(0.024)
Plot size(acre)	0.094	-0.002	0.073	0.122	0.095	-0.009	0.076	0.125	0.103	0.134	0.011	0.199
(Γ_4^i)	(0.018)***	(0.009)	(0.015)***	(0.022)***	(0.019)***	(0.008)	(0.016)***	(0.023)***	(0.036)***	(0.043)***	(0.053)	(0.038)***
Plot size sq. (acre)	-0.001	0.000	-0.000	-0.001	-0.001	0.000	-0.000	-0.001	-0.001	-0.001	-0.000	-0.002
(Γ_5^i)	(0.000)***	(0.000)	(0.000)***	(0.000)***	(0.000)***	(0.000)	(0.000)***	(0.000)***	(0.000)***	(0.000)***	(0.000)	(0.000)***
Cultivate cereals only	0.643	0.137	0.487	0.363	0.686	0.158	0.517	0.388	-0.128	-0.161	-0.072	-0.071
(Γ_6^i)	(0.019)***	(0.022)***	(0.021)***	(0.015)***	(0.020)***	(0.023)***	(0.021)***	(0.015)***	(0.059)**	(0.051)***	(0.069)	(0.057)
Organic fertilizer usage	-0.175	0.296	-0.160	-0.193	-0.178	0.301	-0.166	-0.196	0.139	0.191	0.139	0.054
(Γ_7^i)	(0.022)***	(0.023)***	(0.024)***	(0.016)***	(0.023)***	(0.024)***	(0.025)***	(0.017)***	(0.083)*	(0.075)**	(0.103)	(0.078)
Fertilizer use (100 kg)	0.012	0.002	0.008	0.009	0.011	0.002	0.009	0.008	0.031	0.011	-0.014	0.033
(Γ_8^i)	(0.004)***	(0.003)	(0.005)*	(0.004)**	(0.004)***	(0.003)	(0.005)**	(0.004)*	(0.011)***	(0.021)	(0.027)	(0.013)**
Distance to road(GPS)	0.090	-0.022	0.124	0.094	0.115	-0.015	0.279	0.153	-0.008	-0.015	-0.191	-0.152
(Γ_9^i)	(0.094)	(0.103)	(0.159)	(0.070)	(0.107)	(0.137)	(0.167)*	(0.076)**	(0.129)	(0.101)	(0.250)	(0.137)
Female' sole selling right	0.052	0.174	0.307	-0.059	0.077	0.204	0.322	-0.089	-0.116	0.018	0.095	-0.002
(β_1^i)	(0.080)	(0.091)*	(0.097)***	(0.069)	(0.095)	(0.111)*	(0.111)***	(0.079)	(0.135)	(0.116)	(0.199)	(0.134)
Female's sole planting decision	-0.498	0.397	-0.014	0.046	-0.536	0.440	-0.119	-0.006	-0.464	0.643	0.248	0.064
(β_2^i)	(0.124)***	(0.123)***	(0.146)	(0.065)	(0.141)***	(0.148)***	(0.167)	(0.071)	(0.277)*	(0.220)***	(0.329)	(0.181)
Female's sole output decision	-0.775	0.776	-0.128	-0.268	-0.789	0.823	-0.110	-0.272	-0.271	0.113	-0.164	0.164
(β_3^i)	(0.066)***	(0.061)***	(0.069)*	(0.045)***	(0.069)***	(0.065)***	(0.070)	(0.047)***	(0.220)	(0.177)	(0.296)	(0.178)
Joint selling right	0.101	0.104	0.146	-0.107	0.093	0.107	0.150	-0.128	0.046	-0.020	-0.015	-0.111
(β_4^i)	(0.049)**	(0.055)*	(0.064)**	(0.038)***	(0.052)*	(0.059)*	(0.067)**	(0.040)***	(0.119)	(0.114)	(0.201)	(0.110)
Joint planting decision	-0.139	0.002	0.055	0.003	-0.147	-0.008	0.053	0.005	0.059	0.343	0.015	0.012
(β_5^i)	(0.043)***	(0.045)	(0.051)	(0.028)	(0.044)***	(0.046)	(0.052)	(0.028)	(0.156)	(0.137)**	(0.222)	(0.170)
Joint output decision	-0.085	0.342	0.106	-0.056	-0.080	0.370	0.124	-0.036	-0.099	0.087	-0.147	-0.017
(β_6^i)	(0.055)	(0.050)***	(0.059)*	(0.039)	(0.059)	(0.054)***	(0.061)**	(0.041)	(0.120)	(0.123)	(0.207)	(0.129)
F-statistic	320.10***	57.30***	126.11***	193.23***	328.80***	56.28***	130.88***	201.46***	9.41***	8.62***	7.41***	16.32***
N	29,598	29,598	29,598	29,598	27,322	27,322	27,322	27,322	2,276	2,276	2,276	2,276

Note: *** p< 0.01 ** p< 0.05 * p<0.10.

All six equations are estimated with household and round fixed effects.

Note that subscript i in coefficient α_{1i} and α_{2i} indicates column number where $i = 1, \ldots, 6$. Standard errors are clustered at household level.

Table 1.6: *Cross-equation hypothesis testing results*

	Null Hypothesis	Description of Null Hypothesis	Result	Decision
Pooled	$(\beta_4^m) - (\beta_1^f = \beta_4^f) = 0$	Relative to jointly controlled plots, additional male labor inputs in male-controlled plots and additional female labor inputs in female-controlled plots are identical.	-0.171	Reject
	(Ownership)		(0.097)*	
	$(\beta_5^m) - (\beta_2^f = \beta_5^f) = 0$		-0.256	Reject
	(Planting)		(0.126)**	
	$(\beta_6^m) - (\beta_3^f = \beta_6^f) = 0$		-0.349	Reject
	(Output)		(0.074)***	
Ethiopia	$(\beta_4^m) - (\beta_1^f = \beta_4^f) = 0$		-0.190	Reject
	(Ownership)		(0.116)*	
	$(\beta_5^m) - (\beta_2^f = \beta_5^f) = 0$		-0.302	Reject
	(Planting)		(0.152)**	
	$(\beta_6^m) - (\beta_3^f = \beta_6^f) = 0$		-0.373	Reject
	(Output)		(0.078)***	
Malawi	$(\beta_4^m) - (\beta_1^f = \beta_4^f) = 0$		-0.084	Fail to reject
	(Ownership)		(0.127)	
	$(\beta_5^m) - (\beta_2^f = \beta_5^f) = 0$		-0.359	Reject
	(Planting)		(0.209)*	
	$(\beta_6^m) - (\beta_3^f = \beta_6^f) = 0$		0.073	Fail to reject
	(Output)		(0.186)	

Note: *** $p<0.01$ ** $p< 0.05$ * $p<0.10$. The subscript 1 - 6 in each coefficient represents female sole ownership, female sole planting decision, female sole output decision, joint ownership, joint planting decision, and joint output decision. The superscript in each coefficient represent 'm' for 'male's labor', 'f' for 'female's labor', 'o' for 'other household members' labor', and 'h' for 'hired labor'.

Table 1.7: *Within-equation restriction test results for pooled sample*

	Null Hypothesis	Description of Null Hypothesis	Result	Decision
	Within-equation restrictions			
(1)	$\beta_1^m - \beta_4^m = 0$	Male's labor inputs in female-controlled plots and jointly controlled plots are identical.	-0.049	Fail to reject
	(Ownership)		(0.069)	
	$\beta_2^m - \beta_5^m = 0$		-0.359	Reject
	(Planting)		(0.119)***	
	$\beta_3^m - \beta_6^m = 0$		-0.690	Reject
	(Output)		(0.052)***	
(2)	$\beta_1^f - \beta_4^f = 0$	Female's labor inputs in female-controlled plots and jointly controlled plots are identical.	0.070	Fail to reject
	(Ownership)		(0.084)	
	$\beta_2^f - \beta_5^f = 0$		0.395	Reject
	(Planting)		(0.118)***	
	$\beta_3^f - \beta_6^f = 0$		0.434	Reject
	(Output)		(0.051)***	
(3)	$\beta_1^h - \beta_4^h = 0$	Hired labor inputs in female-controlled plots and jointly controlled plots are identical.	0.048	Fail to reject
	(Ownership)		(0.062)	
	$\beta_2^h - \beta_5^h = 0$		0.043	Fail to reject
	(Planting)		(0.061)	
	$\beta_3^h - \beta_6^h = 0$		-0.211	Reject
	(Output)		(0.032)***	
(4)	$\beta_1^j - \beta_4^j = 0$	Other household labor inputs in female owned plot and jointly owned plot are identical.	0.161	Reject
	(Ownership)		(0.082)**	
	$\beta_2^j - \beta_5^j = 0$		-0.068	Fail to reject
	(Planting)		(0.142)	
	$\beta_3^j - \beta_6^j = 0$		-0.233	Reject
	(Output)		(0.051)***	

Note: *** p< 0.01 ** p< 0.05 * p<0.10.
The subscript 1 - 6 in each coefficient represents female sole ownership, female sole planting decision, female sole output decision, joint ownership, joint planting decision, and joint output decision.
The superscript in each coefficient represent 'm' for 'male's labor', 'f' for 'female's labor', 'o' for 'other household members' labor', and 'h' for 'hired labor'.

Chapter 2

Microcredit and household labor sharing: A theoretical approach

2.1 Introduction

Agricultural households in developing countries commonly cope with market failures using social networks. Economists have studied the roles of mutual credit, social learning, and information flows through these social networks (Munshi, 2011). Like social networks, labor sharing may be used by agricultural households in response to market failures. Labor sharing is significant for several reasons, including seasonal labor deficiency, lack of working capital, and irregular tasks that influence farm productivity. However, the economics of labor sharing networks have received less critical attention relative to other studies on informal networks.

Therefore, the purpose of this study is to address the gap in our understanding of the relationship between liquidity constraint and household labor sharing networks for agricultural production. While increased liquidity from the introduction of microcredit could potentially provide farmers with a substitute for sharing arrangements, this may not be the case if labor sharing is not a symptom of illiquid village economies. If positive network effects (or teamwork production) incentivize households to maintain or increase networking with neighbors, households' ability to receive loans may have no influence on optimal sharing choices. Krishnan and Sciubba (2009) suggest network externalities in a labor sharing network are positive, which means farmers produce more under labor sharing network compared to working alone. For this reason, this research into informal labor markets addresses the following questions using a theoretical approach:

1) Does microcredit impact labor sharing arrangements in rural economies?

2) What is the role of network effects (or teamwork production) on labor sharing groups?

Recent studies have shown that credit availability influences household labor allocation decisions. Lovo (2012) demonstrated that a liquidity constraint causes households to supply more off-farm labor and hire fewer workers. Fink et al. (2014) showed that credit availability decreases households' seasonal off-farm labor supply, which explains the relationship between liquidity constraints and consumption smoothing. Jack et al. (2016) also suggested that loosening borrowing constraints decreases child labor in Kenya.

However, recent experimental results have suggested that a greater prevalence of microcredit does not increase household on-farm labor supply in Ethiopia (Tarozzi et al., 2015), Mexico (Angelucci et al., 2015), or Bosnia (Augsburg et al., 2015). Although several studies have investigated the relationship between household labor allocation and microcredit, the research has tended to ignore labor sharing arrangements. In particular, agricultural labor sharing in Sub-Saharan African countries has not received much attention, despite its common usage across the continent.

Labor sharing, which is reciprocal and mutually beneficial for participating farmers, is important because completing time-specific planting or harvesting tasks often demands heavy labor for higher production levels. Several studies, including Gilligan (2004), Krishnan and Sciubba (2009), and Mekonnen and Dorfman (2017), have attempted to explain the economics of labor sharing in developing countries. Gilligan (2004), who examined the determinants of labor sharing in Indonesia, showed that economic incentives, such as plot irrigation or higher percentages of privately-owned land by a household, make farmers more likely to share labor with other neighbors. Krishnan and Sciubba (2009) modeled the synergy effect of labor sharing networks. They attributed villagers engaging in labor sharing to these production synergies, despite the need for villagers to reciprocate with their own labor time.

Takasaki et al. (2014) showed that labor sharing and hiring could substitute each other if credit is introduced in Peru. The fact that households must spend their time in the communal forest explains why farmers shift from labor sharing to hiring once they can acquire working capital through borrowing. Takasaki et al. (2014)'s study on labor sharing mainly examined the effect of liquidity constraints on forest clearing in the de facto common resource. However, it is ambiguous whether shared labor supply on private farms change once a household receives a microcredit loan.

Our study is important for two reasons. First, previous studies have suggested that microcredit loans help farmers change the structure of labor supply (Augsburg et al., 2015; Bandiera et al., 2017). However, if we do not include labor sharing in farm labor supply, then previous studies may not accurately account for actual labor allocation after households receive loans from the microcredit institution. This inaccuracy could lead to misinterpretation of the policy effects of alleviating borrowing constraints on family labor days.

Second, several studies have shown that microcredit does not substantially increase household income despite increases in the household's input investment (Meager, 2019). These heterogeneous effects may be the result of network effects on labor sharing impeding households' responses to the policy or programs. The importance of village networking may mean that farmers with more working capital are not able to change their labor supply easily, because severing the mutual agreements and social ties integral to the network might have a higher cost than maintaining it. This can actually limit households' labor allocation adjustment, which can reduce the effects of microcredit loans on agricultural households.

Our study addresses these concerns in two ways. First, the study models labor sharing decisions on a two-period model that includes liquidity constraint in the household budget constraint. Although Gilligan (2004)'s work explained the determinants of labor sharing, it only examined a static model that does not properly include the borrowing and liquidity constraints. By contrast, this study examines the dynamics of labor allocation using the two-period household model.

Second, this study identifies the relationship between labor sharing and family labor in terms of both labor supply and demand. Previous studies related to credit availability and labor seasonality have focused on labor supply decisions. [1] This study theoretically identifies the impact of liquidity constraints on both labor demand and supply of labor sharing in the agricultural household under symmetric reciprocity.

The results of the theoretical model show that households with greater loan sizes tend to supply more labor from shared labor networks and invest more inputs. Loan size increases the disposable income in the first period, and a household must make greater return payments in the second period. A household balances its consumption level in the first and second periods by increasing the investment of inputs and increasing labor sharing. However, changes in family labor are conditional on leisure preferences and cost of inputs. If household preferences for leisure become higher, then family labor supply decreases with loan size.

A household may reduce its labor sharing and input investment if the interest rate decreases due to microcredit loans that are conditional on loan size remaining unchanged. Decreased shared labor days are substituted by family labor. Assuming a household allocates labor and inputs at an efficient level, taking microcredit loans at lower interest rates increases households' disposable income in the second period. Because a household maximizes its utility by smoothing consumption, the household's consumption level in the first period also increases by reducing input and labor sharing costs.

This study provides a theoretical model introducing network effects of labor sharing, which increase productivity and incentivize the labor sharing arrangements. Network effects of labor sharing reduce households' responsiveness of labor allocation to credit. Once the network effect is high enough, then a household becomes reluctant to change labor or input allocation even if they receive microcredit loans or the amount borrowed increases. Smaller degrees of labor and input changes suggest that the network effects of labor sharing impede households from changing the structure of labor supply. These findings support current studies on why household labor does not respond to the microcredit loan.

The following sections of this chapter include: the literature review in Section 2.2, the

[1] For example, see Fink et al. (2018), Bandiera et al. (2017), and Tarozzi et al. (2015). Dupas et al. (2014) found that the intertemporal labor supply decisions of Kenyan taxi drivers decrease as their daily income meets their cash needs.

theoretical model and its results in Section 2.3, and the chapter summary in Section 2.4.

2.2 Literature review

2.2.1 Labor sharing in developing countries

Labor sharing has been extensively documented by anthropologists such as Erasmus (1956) and Moore (1975). Sharing arrangements are prevalent where labor-intensive agriculture is practiced, such as in rice cultivation (Moore, 1975). Co-operative labor (i.e., the wider concept of labor sharing) includes joint performances, series of sequentially-related work, working groups, and working relationships other than those between employer and employee. Labor sharing exists in both developed and developing countries.[2] A recent study concluded that labor sharing is a team production in which farmers are motivated by reciprocal altruism (Macfarlan et al., 2012).

Labor seasonality in developing countries is common. Households often experience labor shortages during planting and harvest seasons, but labor surplus during lean seasons. For this reason, even the demand for child labor rises when a household faces a labor shortage (Guarcello et al., 2010). Demand for labor sharing also emerges for similar reasons, and it is more extensive. Despite the fact that labor sharing is a nonmarket institution, anthropological research suggests that farmers share labor 1) when a task must be completed in a specific time period, and there is a labor shortage; 2) when farmers complete occasional or irregular tasks; 3) when farmers experience psychological motivations; 4) when farmers lack funds to hire subsistence-level farmers (Moore, 1975). Incentives such as reputation mechanisms, social norms, peer pressure, and higher returns for teamwork also influence households to participate in labor sharing (Gilligan, 2004; Takasaki et al., 2014).

Traditionally, sharing networks and reciprocal exchanges were prevalent (Fafchamps and Gubert, 2007) and critical (Schechter and Yuskavage, 2011) in developing countries.[3] Labor

[2] Artz et al. (2010) used previous studies related to machinery and labor sharing in developed countries. Their study concluded that small-scale farmers in developed countries share labor by sharing machinery to reduce transaction costs.

[3] For example, informal credit networks, savings groups, funeral insurance, and working groups are infor-

sharing is a type of interpersonal exchange which typically includes two arrangements of working groups: reciprocal labor and festive labor (Erasmus, 1956). Reciprocal labor is a bilateral labor arrangement between two farmers where one farmer compensates another once they have received help during the labor peak season. Farmers may also arrange before the farming season starts for a group to work for several days on each household's farm. This type of bilateral relationship usually requires farmers to be homogeneous in terms of the crop type they cultivate, arable farm size, and income level (Gilligan, 2004; Moore, 1975). It also requires trust within the group that no one will fail to complete their assigned work on group members' farms. Farmers in the early years of labor sharing tend to recruit many neighbors, which can generate redundant labors. For this reason, experienced farmers may reduce the group size to make the labor sharing group more efficient. Under the reciprocity of labor sharing, reputation mechanisms make it unlikely that farmers will fail to complete their duties, as their work will be paid back by neighbors (Krishnan and Sciubba, 2009). Reciprocal labor arrangements are common among kinship or close neighbors since they are aware of relatives' or close neighbors' labor productivity.

Festive labor does not require reciprocity of labor, but rather the hosting farmer provides drinks or food to the working group. As Krishnan and Sciubba (2009) explained, this means that festive labor groups are bigger and their participants are more heterogeneous compared to reciprocal labor arrangements.

Mekonnen and Dorfman (2017) completed a study examining the learning effect and synergy effect of labor sharing in Ethiopia. They found that there is no learning effect because the labor sharing networks they studied are formed for one season and do not last continuously. However, they found evidence for synergy effects, which is consistent with Gilligan (2004), who explained the labor sharing advantage in terms of teamwork production.

mally formulated groups within the village that share idiosyncratic risks. Previous studies have examined the roles of networks in terms of risk-sharing (De Weerdt and Dercon, 2006; Dercon and Krishnan, 2000; Fafchamps and Lund, 2003; Mobarak and Rosenzweig, 2013) and technology adoption (Bandiera and Rasul, 2006; Conley and Udry, 2010; Foster and Rosenzweig, 1995). Banerjee et al. (2013) also explored the role of networks in microfinances.

2.2.2 Microcredit and household labor

Another view as to why farmers share labor posits that labor sharing arises as an alternative labor source for poor farmers facing credit and labor market imperfections. (Gilligan, 2004). Scarcity of cash increases labor sharing (Moore, 1975) by preventing farmers from hiring labor (Erasmus, 1961). Labor and credit market failure is common in Sub-Saharan African countries, and it is frequent cause of the well-known non-separation problem (Benjamin, 1992; LaFave and Thomas, 2016).

Interventions to alleviate liquidity constraints via microcredit loans have become increasingly popular over the previous decades in the developing world. However, the lack of evidence of microcredit impacts in the socioeconomic field has led researchers to evaluate using randomized control trials (RCT) (Dahal and Fiala, 2018). A special issue of the *AEJ: Applied Economics* published in 2015 compiled effects of microcredit loans on agricultural production, labor market, and livelihood. Despite its prevalence in developing countries, the socioeconomic impact of microcredit was found to be limited in Ethiopia (Tarozzi et al., 2015), Morocco (Crépon et al., 2015), and Mongolia (Attanasio et al., 2015). Better accessibility of microcredit is more closely related to agricultural input investments than investment in non-farm business activities. Tarozzi et al. (2015) and Crépon et al. (2015) showed that the majority of loans received by their study's respondents were used for production-related activities, such as payment of hired workers' wages, payment for land and inputs, and purchase of animals and equipment. In Ethiopia, microcredit did not impact household labor supply changes substantially (Tarozzi et al., 2015).

By contrast, several recent studies found that borrowing conditions strongly influence labor allocation decisions. Jack et al. (2016) used experimental evidence to suggest that loosening borrowing constraints can decrease child labor and increase school enrollment rates, especially for girls in Kenya. Fink et al. (2018) showed that liquidity constraints influence rural labor markets of casual labor in Zambia. Credit market participation is the most important source of liquidity, as it enables farmers to hire on-farm casual labor.

Microcredit also increases the village wage level. For example, Kaboski and Townsend

(2012) found that the expansion of microcredit in Thailand villages increases villages' wages and household income. Microcredit availability also decreases poverty levels in India (Burgess and Pande, 2005). A recent study by Breza and Kinnan (2018) suggested microcredit participation also increases daily wages in India. Another advantage of microcredit is that it allows farmers to choose the ideal time to sell products. Credit availability allows farmers to sell their crops at a high price and buy at a low price (Burke et al., 2014).

These heterogeneous effects of credit on labor markets could arise from differences in both the form of borrowing and variations in the conditions farmers face. Dimble and Mobarak (2019) and Field et al. (2013) explained that considerations must be made regarding use of the grace period rather than immediate repayment of credit. Morvant-Roux (2011) also explained that microcredit still excludes most of the subsistence farmers in developing countries, causing heterogeneous effects of microcredit on the agriculture and labor markets.

Even though there are many debates on the effects of microcredit services, recent studies related to microcredit do not include the labor sharing supply of the household. Thus, the research gap reflects ambiguity in the field regarding the effect of microcredit on labor sharing supply. Additionally, a formal theoretical model that includes liquidity constraint and network effects of labor sharing is necessary to address this gap in the literature.

2.3 Theoretical model of labor sharing

In this section, we build a theoretical framework of the relationships between household labor supply and credit constraints using a two-period approach that modifies Gilligan (2004)'s static model and includes liquidity constraint. The first period of this model includes data collected from the planting to harvesting seasons. In the second period, the model is used to calculate household income generated from selling harvested products.

2.3.1 Assumptions

With this study, we focus on changes regarding family and shared labor with respect to the microcredit loan. Accordingly, we restrict the model by several assumptions. First, the model assumes that labor sharing has no redundant labor, with all duties fully completed under the monitor of the host farmer. In other words, family and shared labors are fully substitutable without explicit monitoring costs.

Second, labor decisions depend on the endowment of working capital and arable land (Eswaran and Kotwal, 1986). Farmland is constant over the farming season. Households in general make the land use or sale decision to either buy, lease, or fallow land before the planting season starts. For this reason, farm sizes seldom change during the cultivation season. Furthermore, input supply is assumed to be efficient, and agricultural productivity per acre does not drastically increase by increasing inputs.

Third, there is no rural labor market in this model. Households in the model do not employ workers and also do not get off-farm jobs from outside. The purpose of this study is to examine the relationship between labor sharing and family labor. As such, this study does not examine labor hiring. While this assumption is restrictive, rural labor markets in developing countries are usually imperfect.

Fourth, the model assumes reciprocity of labor sharing which means that the household's outgoing labor sharing days on other household farms are equal as incoming labor sharing days. Besides, that assumption is most likely to hold when farmers have long term relationships, which commonly occurs in villages with long family residential history (Downey, 2010).

Lastly, the model assumes that all of the household's disposable income must be consumed by the end of the second period.

2.3.2 Basic model

In the first period of the theoretical model, a household uses its financial endowment to purchase inputs or to pay for the labor sharing related costs. A household also borrows a loan in the first period and uses it either for input expenditure, labor sharing costs, or consumption. In the second period, a household sells harvested products and gains income only from its farmland. All households are permitted to borrow in the first period and pay back credit in the second period. A household's production consists of the labor inputs of family labor (N_f) and shared labor (N_s). A household's time endowment is $\overline{N}$, which consists of family labor and shared labor. Thus, each household's time constraint is:

$$\overline{N} - N_f - N_s \geq 0 \tag{2.1}$$

A household in the first period works on its own farm or shares labor with its neighbors. A household's consumption in the first and second periods are, respectively:

$$\overline{M} + B - w_x X - c_s N_s \geq c_1$$

and

$$py - (1 + r)B \geq c_2$$

where $\overline{M}$ is the initial wealth endowment of the household; p is the unit price of outputs; w_x and c_s are the unit costs of inputs and shared labor, respectively; $w_x X$ is the total input cost; $c_s N_s$ is the cost of labor sharing (e.g. networking and search costs); y is the agricultural output; and c_1 and c_2 are consumption in the first and second periods, respectively.

Gilligan (2004) also considered the food or drink expenditures and the compensation provided to sharing group members by neighbors as non-reciprocal festive labor. However, under the reciprocity assumption, food expenditure cancels out, because neighbors will also provide foods at a later time. Accordingly, I considered the cost of $c_s N_s$ to be the transaction costs associated with searching and managing the network. Additionally, I treat the price of output p as a numeraire, meaning that the output price $p = 1$ holds.

A household's inter-temporal utility $U(c)$ is expressed as:

$$U(c) = ln(c_1) + \beta ln(c_2) \tag{2.2}$$

where $\beta < 1$ is the discount factor for the second period; $U' > 0$; and $U'' < 0$.

It is likely that two major incentives encourage a household to produce with the associated sharing group. We use the term "network effects" throughout the paper to refer to both elements. First, the timing of some specific tasks such as seedling or harvesting influences the household's production level. If there are tasks that the household must finish in a short period, then they are looking for a sizable labor force. Productivity through labor sharing to finish a specific task within a short time is greater compared to working alone for several days, which carries a risk of losing outputs. This is the first case of network effects.

Second, there may be network effects through chatting and working together that help save time compared to working alone. If the incentives of labor sharing are lesser than the incentives of family labor, a household would not share the labor with their neighbors since it is reciprocal and the household has to provide corresponding labor for the counter working days it received.

In this paper, the parameter α represents the potential network effects of two different incentives. We assume that the marginal benefit "α" of participating in a labor sharing group remains constant as the sharing network becomes larger.

Furthermore, the model expresses total effective labor provided on the farm as $N_f + (1+\alpha)N_s$. In general, there are no differences of labor productivity between the family and shared workers. Since it is possible to measure the time constraint as $N_f = \overline{N} - N_s$, total labor allocated in the farm becomes $\overline{N} + \alpha N_s$. We considered the general production case using the Cobb-Douglas production function $y = X^{\theta}(\overline{N} + \alpha N_s)^{1-\theta}$. Unlike linear production functions, the Cobb-Douglas function is concave and exhibits decreasing returns to scale as there are more inputs and labor used. The model also assumes both microcredit amount and interest rates are exogenously determined. The household problem then becomes:

$$\max_{c_1, c_2} \quad ln(c_1) + \beta ln(c_2) \tag{2.3}$$

$$s.t.\ \overline{N} - N_f - N_s \geq 0$$

$$\overline{M} + B - w_x X - c_s N_s = c_1$$

$$X^{\theta}(N_f + (1+\alpha)N_s)^{1-\theta} - (1+r)B = c_2$$

$$N_f > 0, X > 0, N_s > 0, B > 0, c_1 \geq 0, c_2 \geq 0$$

In the two-period model, we assume that $\beta > r$. If the interest rate of the loan is higher than the discount rate, the household prefers to borrow more credit, which causes a corner solution.

After substituting the values for the budget and time constraints into the utility function, the household problem can be simplified as follows:

$$\max_{N_s, X} \quad ln(\overline{M} + B - w_x X - c_s N_s) + \beta ln(X^{\theta}(\overline{N} + \alpha N_s)^{1-\theta} - (1+r)B) \tag{2.4}$$

The first-order conditions for labor sharing and inputs are:

$$\frac{\partial u}{\partial N_s} : \frac{c_s}{\overline{M} + B - w_x X - c_s N_s} = \frac{\beta(1-\theta)\alpha X^{\theta}(\overline{N} + \alpha N_s)^{-\theta}}{X^{\theta}(\overline{N} + \alpha N_s)^{1-\theta} - (1+r)B} \tag{2.5}$$

$$\frac{\partial u}{\partial X} : \frac{w_x}{\overline{M} + B - w_x X - c_s N_s} = \frac{\beta\theta(\overline{N} + \alpha N_s)^{1-\theta} X^{\theta-1}}{X^{\theta}(\overline{N} + \alpha N_s)^{1-\theta} - (1+r)B} \tag{2.6}$$

Equations (2.5) and (2.6) are simplified as:

$$X = \frac{\theta}{1-\theta}\frac{c_s}{w_x}\frac{\overline{N} + \alpha N_s}{\alpha}$$

After inserting $X = \frac{\theta}{1-\theta}\frac{c_s}{w_x}\frac{\overline{N}+\alpha N_s}{\alpha}$ into the equation (2.5), the optimal shared labor N_s^*

and family labor N_f^* can be expressed as:

$$N_s^* = \frac{\beta(1-\theta)(\overline{M}+B)}{c_s(1+\beta)} + \frac{1+r}{\alpha(1+\beta)}\left(\frac{1-\theta}{\theta}\frac{\alpha w_x}{c_s}\right)^{\theta} B - \frac{1+\beta\theta}{1+\beta}\overline{N} \tag{2.7}$$

and

$$N_f^* = \overline{N} - N_s^* = \frac{\beta(1-\theta)}{1+\beta}\overline{N} - \frac{\beta(1-\theta)(\overline{M}+B)}{c_s(1+\beta)} - \frac{1+r}{\alpha(1+\beta)}\left(\frac{1-\theta}{\theta}\frac{\alpha w_x}{c_s}\right)^{\theta} B \tag{2.8}$$

Because a household's time endowment consists of family and shared labor, labors can be substituted for each other. The optimal input level X^* is:

$$\begin{aligned} X^* &= \frac{\theta}{1-\theta}\frac{c_s}{w_x}\frac{\overline{N}}{\alpha} + \frac{\theta}{1-\theta}\frac{c_s}{w_x}N_s^* \\ &= \frac{\theta}{1-\theta}\frac{c_s}{w_x}\left(\frac{1-\alpha+\beta(1-\alpha\theta)}{\alpha(1+\beta)}\right)\overline{N} + \frac{\theta}{w_x}\frac{\beta}{1+\beta}(\overline{M}+B) + \frac{1+r}{1+\beta}\left(\frac{\theta}{1-\theta}\frac{c_s}{w_x}\frac{1}{\alpha}\right)^{1-\theta} B \end{aligned} \tag{2.9}$$

Optimal consumption level c_1^* and c_2^* are:

$$c_1^* = \frac{\overline{M}+B}{1+\beta} - \frac{c_s\overline{N}}{1+\beta}\frac{\theta(1-\alpha)+\beta(1-\theta)-(\alpha\beta\theta+1)}{\alpha(1-\theta)} - \frac{1+r}{1+\beta}A^{\theta}\frac{(1-\theta)\alpha w_x^2-\theta c_s^2}{\theta c_s}$$

$$\begin{aligned} c_2^* &= \frac{1}{1+\beta}\left[\frac{1-\alpha+\beta(1-\alpha\theta)}{A}\overline{N} + \frac{\beta\theta}{w_x}(\overline{M}+B) + (1+r)A^{\theta-1}B\right]^{\theta} \\ &\quad \times \left[\frac{\alpha\beta(1-\theta)(\overline{M}+B)}{c_s} + (1+r)A^{\theta}B + (1+\beta-\alpha(1-\beta\theta)\overline{N}\right]^{1-\theta} - (1+r)B \\ &= \frac{1}{1+\beta}C^{\theta}D^{1-\theta} - (1+r)B \end{aligned}$$

where $A = \frac{1-\theta}{\theta}\frac{\alpha w_x}{c_s}$, $C = \left[\frac{1-\alpha+\beta(1-\alpha\theta)}{A}\overline{N} + \frac{\beta\theta}{w_x}(\overline{M}+B) + (1+r)A^{\theta-1}B\right]$ and $D = \left[\frac{\alpha\beta(1-\theta)(\overline{M}+B)}{c_s} + (1+r)A^{\theta}B + (1+\beta-\alpha(1-\beta\theta)\overline{N}\right]$.

Comparative Statics Using comparative statics analysis, we determined if household labor and input supply increase or decrease in relation to changes to the household's credit condition (e.g., change of loan amount or change of interest rates). Equations (2.10) to (2.12) express labor and input changes with respect to the loan amount B. Results show that a household's labor sharing and input expenditure increase with microcredit loan size, while family labor supply decreases. If the disposable income in the first period increases, a household can either increase its input expenditure or consumption level. However, the increased loan size also increases the amount of credit that must be repaid in the second period, so households choose to produce more by investing in the labor sharing and inputs. Because of the network effect, farmers prefer to share their labor or increase input purchase to increase farm productivity. For non-zero values of α, family labor is less likely to be supplied in these conditions because the labor productivity of family is lower relative to labor sharing.

$$\frac{\partial N_s^*}{\partial B} = \frac{\beta(1-\theta)}{c_s(1+\beta)} + \frac{1+r}{\alpha(1+\beta)}\left(\frac{1-\theta}{\theta}\frac{\alpha w_x}{c_s}\right)^{\theta} > 0 \tag{2.10}$$

$$\frac{\partial N_f^*}{\partial B} = -\frac{\beta(1-\theta)}{c_s(1+\beta)} - \frac{1+r}{\alpha(1+\beta)}\left(\frac{1-\theta}{\theta}\frac{\alpha w_x}{c_s}\right)^{\theta} < 0 \tag{2.11}$$

$$\frac{\partial X^*}{\partial B} = \frac{\theta}{w_x}\frac{\beta}{1+\beta} + \frac{1+r}{1+\beta}\left(\frac{\theta}{1-\theta}\frac{c_s}{w_x}\frac{1}{\alpha}\right)^{1-\theta} > 0 \tag{2.12}$$

$$\frac{\partial c_1^*}{\partial B} = \frac{1}{1+\beta} > 0 \tag{2.13}$$

$$\frac{\partial c_2^*}{\partial B} = \frac{\theta}{1+\beta}\left(\frac{D}{C}\right)^{1-\theta}\left(\frac{\beta\theta}{w_x} + (1+r)A^{\theta-1}\right) + \frac{1-\theta}{1+\beta}\left(\frac{C}{D}\right)^{\theta}\left((1+r)A^{\theta} + \frac{\alpha\beta(1-\theta)}{c_s}\right) - (1+r) \tag{2.14}$$

Changes in the network effect of labor sharing influences the household's optimal amount of labor supplied and input expenditure. As the network effect α increases, a household responds by decreasing its labor supply into the labor sharing network, and input expenditure becomes smaller even if the household receives a microcredit loan. Likewise, a household increases its family labor supply responding to the higher network effects. However, decreases in network effect increases shared labor supply and input purchase while family labor supply decreases.For every higher assumptions about the positive synergies associated with shared labor (i.e. as α increases to infinity), the second term of equations (2.10) to (2.12) goes to 0 which means that changes in the household labor supply and input expenditures become smaller. Comparative statics in equations (2.10) to (2.12) indicates that the impact of loan sizes depends on the size of α.

The family and shared labor substitution responds to the cost of sharing c_s. In other words, higher labor sharing costs reduce the effect of microcredit loans on both family and shared labor, and a household is less likely to respond to changes in loan size by increasing shared labor. Accordingly, high labor sharing costs blunt household's labor allocation on both family and shared labor. Input changes respond to both input and labor sharing cost changes. If either input cost increases or labor sharing cost decreases, a household is less likely to increase the input supply. Comparative statics of loan size indicates that a household is more likely to supply shared labor and to purchase inputs if corresponding costs are low.

Households also consume more in the first period as loan size increases. However, the magnitude of the consumption change in the first period depends on the discount factor β. If the household's discount factor is low and they do not value the second-period consumption relative to the first period, first-period consumption will increase further. In the second period, consumption level change is ambiguous.

Comparative statics of interest rates can be considered in two ways. An introduction of microcredit can increase or decrease interest rates compared to other villages without microcredit loan institutions.[4] In general, villagers take loan credit from informal institutions such as money lenders, whose interest rates are relatively high relative to formal banks or microcredit institutions.[5] Accordingly, villagers may benefit from microcredit services through reduced interest rates. Equation (2.15) shows that a household is less likely to demand shared labor as interest rates decrease. Input demand also decreases with reduced interest rates.

The reason why the household's shared labor supply and input expenditure from outside decrease as the interest rate decreases is because a household considers the relative cost of consumption for the current time and the future. For a fixed amount borrowed, when microcredit services reduce interest rates, the household's disposable income in the second period increases. That increases second period consumption, and drives down the optimal marginal utility of consumption level. The household's optimal response then is to increase first period consumption, which is done at the expense of investing in shared labor and input expenditure. Since farmers have to pay for inputs and shared labor, reduced interest rates decrease their demand for labor sharing and inputs, which are then substituted by family labor. For this reason, the comparative statics of the first-period consumption is negative. Reducing interest rates increases consumption in the second period, and households seek to smooth consumption by reducing other expenditures. In the two-period model with no savings and fixed loan sizes, the household chooses to reduce costs on labor sharing and input purchases.

[4] The purpose of the microcredit loan is to provide credit service to the impoverished. However, not every microcredit institution provides loans at the lowest interest rate compared to other credit service institutions.

[5] Note that villagers have the possibility to increase their loan amount once the interest rate decreases. However, I assume loan amount to be exogenous and that a household does not respond to changing interest rates.

The reduction of interest rates by introducing microcredit loans leads a household to decrease its demand in the labor sharing network, which may lead it to decrease labor days provided to the sharing group assuming the reciprocity of labor sharing. As a result, the household experiences greater time endowment, and may then substitute the shortage of labor from family members. Under the assumption that land size does not change across the season, the introduction of a microcredit loan does not lead a household to shift up the production curve unless it adopts new technologies.

Conversely, households with microcredit loans subject to higher interest rates increase labor sharing and input supply. Family labor also decreases if interest rate increases, because the productivity of family labor is lower than that of shared labor. If the interest rate increases, a household produces more by supplying shared labor and inputs. Thus, the household reduces its first period consumption and smooths consumption in the second period.

$$\frac{\partial N_s^*}{\partial r} = \frac{1}{\alpha(1+\beta)} \left(\frac{1-\theta}{\theta} \frac{\alpha w_x}{c_s} \right)^{\theta} B > 0 \tag{2.15}$$

$$\frac{\partial N_f^*}{\partial r} = -\frac{r}{\alpha(1+\beta)} \left(\frac{1-\theta}{\theta} \frac{\alpha w_x}{c_s} \right)^{\theta} B < 0 \tag{2.16}$$

$$\frac{\partial X^*}{\partial r} = \frac{1}{1+\beta} \left(\frac{\theta}{1-\theta} \frac{c_s}{w_x} \frac{1}{\alpha} \right)^{1-\theta} B > 0 \tag{2.17}$$

$$\frac{\partial c_1^*}{\partial r} = -\frac{1}{1+\beta} \left(\frac{1-\theta}{\theta} \frac{\alpha w_x}{c_s} \right)^{\theta} \frac{(1-\theta)\alpha w_x^2 - \theta c_s^2}{\theta c_s} < 0 \tag{2.18}$$

$$\frac{\partial c_2^*}{\partial r} = \frac{\theta}{1+\beta}\left(\frac{D}{C}\right)^{1-\theta} A^{\theta-1}B + \frac{1-\theta}{1+\beta}\left(\frac{C}{D}\right)^{\theta} A^{\theta}B - B \tag{2.19}$$

Network effects, α, have important consequences for the magnitude of predicted microcredit impacts on household labor and input expenditure. With a lower network effect, the impact of the loan size and interest rates on labor supply becomes smaller. In other words, lower network effects of labor sharing reflect farm households not to prefer to reallocate their labor on both family labor and labor sharing network regardless of loan taking. Instead, an impact of loan on input allocation become higher which means households prefer to purchase more inputs with a lower network effect.

If networking with neighbors for labor sharing brings high positive network effects on household production, a household is not likely to change its labor or input allocation, even if it receives more credit and greater benefits from lower interest rates. For this reason, the effect of microcredit loans in highly effective working groups is lower compared to farmers without labor sharing groups or whose groups suffer from low network effects.

Synergy effects of labor sharing networks further decrease labor and input changes. If the network effect α increases with the labor sharing group size, then synergy effects exist. The existence of synergy effects increases network effect size α to be greater compared to cases with no synergy effects, and relative changes of labor and inputs become smaller. Accordingly, households keep their labor supply structure and input expenditure if both network and synergy effects exist, even though credit service interest rates decrease.

Farmers who experience high network effects enjoy greater levels of consumption as interest rates decrease. Households working in highly effective groups are less likely to change their input allocation, but rather increase consumption level. For example, comparative statics in equations (2.18) to (2.19) shows that a higher network effect α increases consumption changes in both the first and second periods. Additionally, members of the high network effect group increase their first-period consumption level more than members of the low network effect groups.

Labor and input costs (c_s and w_x) and loan amounts (B) also determine labor and input supply changes in the household. Equations (2.15) to (2.17) indicate that loan size, input costs, and labor sharing costs influence the degree of labor and input expenditure changes. As loan size increases, a household becomes more responsive to labor supply and input expenditure changes. However, an increase in the searching and managing costs of labor sharing decreases the relative number of labor days supplied by both sharing group and family. If the cost of labor sharing is low, the household is more sensitive to changes to labor supply and input expenditure. Input costs have the opposite effect. High input costs lead a household to be more responsive to labor supply instead of changing input expenditure. This means that a household substitutes family and shared labor rather than input purchase if input cost is high. In the case that fertilizer cost is low, family and shared labors are less responsive to interest rate changes, but the degree of change of input expenditure becomes greater.

Lastly, lower valuation of the second period utility stimulates the household's responses to input changes. The household's valuation in the second period is explained using β. If β approaches 1, this indicates that the household's preferences for the first and second periods are similar. With the value $\beta \rightarrow 1$, consumption level in the second period increases relative to the first period, and the household becomes less sensitive to labor and input changes. Thus, the degree of change in labor sharing and input expenditure grows smaller.

In the case that a household valuates more in the first period than in the second period, which is expressed by $\beta \rightarrow 0$, its consumption in the first period relative to the second period increases. The household is then less likely to supply shared labor and purchase inputs, but more likely to increase the family labor supply.

The basic model demonstrates the comparative statics of labor and inputs with the change of loan size and interest rate. Even though a household supplies more shared labor and purchases more inputs with the increase of loan size or interest rates, the degree of the effect depends on the network effects, labor sharing cost, input costs, and the household's preferences in each period.

2.3.3 Extended model

The basic model only considers the family and shared labor to be available for the household's time use. In the extended model, household time endowment consists of $\overline{N} = N_f + N_s + R$, where R is leisure. Additionally, in the extended model, a household maximizes its utility from consumption in both periods and leisure. Following Jayachandran (2006), the household has Stone-Geary preferences over leisure. The household's utility function is $u(c, R) = ln(c_1) + \beta ln(c_2) + \gamma ln(R)$, where $\gamma = \frac{\Gamma}{1-\Gamma}$.[6] A household maximizes utility by allocating labor, leisure, inputs, and consumption at the optimal level.

$$\max_{c_1,c_2,R} \quad ln(c_1) + \beta ln(c_2) + \gamma ln(R) \tag{2.20}$$

$$s.t.\ \overline{N} - N_f - N_s - R = 0$$

$$\overline{M} + B - w_x X - c_s N_s = c_1$$

$$X^\theta (N_f + (1+\alpha)N_s)^{1-\theta} - (1+r)B = c_2$$

$$c_1 \geq 0, c_2 \geq 0, N_f > 0, X > 0, N_s > 0, R > 0, B > 0$$

By substituting a budget constraint and time constraint into the utility function, the household problem is simplified as:

$$\max_{N_f,N_s,X} \quad ln(\overline{M}+B-w_x X-c_s N_s)+\beta ln[X^\theta (N_f+(1+\alpha)N_s)^{1-\theta}-(1+r)B]+\gamma ln(\overline{N}-N_f-N_s) \tag{2.21}$$

The first-order conditions for the family labor, shared labor, and inputs are:

[6] The term $\gamma = \frac{\Gamma}{1-\Gamma}$ is interpreted as a parameterized household's preference over its leisure and, hence, labor under the CRRA condition. The level of Γ determines the degree of curvature. Accordingly, the utility function of the household is the constant relative risk aversion utility function.

$$\frac{\partial u}{\partial N_s}: \frac{c_s}{\overline{M} + B - w_x X - c_s N_s} + \frac{\gamma}{\overline{N} - N_f - N_s} = \frac{\beta(1+\alpha)(1-\theta)X^{\theta}(N_f + (1+\alpha)N_s)^{-\theta}}{X^{\theta}(N_f + (1+\alpha)N_s)^{1-\theta} - (1+r)B} \tag{2.22}$$

$$\frac{\partial u}{\partial N_f}: \frac{\beta(1-\theta)X^{\theta}(N_f + (1+\alpha)N_s)^{-\theta}}{X^{\theta}(N_f + (1+\alpha)N_s)^{1-\theta} - (1+r)B} = \frac{\gamma}{\overline{N} - N_f - N_s} \tag{2.23}$$

$$\frac{\partial u}{\partial X}: \frac{w_x}{\overline{M} + B - w_x X - c_s N_s} = \frac{\beta\theta X^{\theta-1}(N_f + (1+\alpha)N_s)^{1-\theta}}{X^{\theta}(N_f + (1+\alpha)N_s)^{1-\theta} - (1+r)B} \tag{2.24}$$

By combining equations (2.22) and (2.23), we have:

$$\frac{c_s}{\overline{M} + B - w_x X - c_s N_s} = \frac{\alpha\beta(1-\theta)X^{\theta}(N_f + (1+\alpha)N_s)^{-\theta}}{X^{\theta}(N_f + (1+\alpha)N_s)^{1-\theta} - (1+r)B} \tag{2.25}$$

Then equations (2.24) and (2.25) are simplified as:

$$X = \frac{\theta}{\alpha(1-\theta)}\frac{c_s}{w_x}(N_f + (1+\alpha)N_s) \tag{2.26}$$

In the equation (2.26), input X is a function of N_f and N_s. By substituting equation (2.26) into the equation (2.23), I derived family labor N_f as a function of shared labor N_s.

$$N_f = \frac{\beta(1-\theta)}{\gamma + \beta(1-\theta)}\overline{N} + \frac{\gamma(1+r)B}{(\gamma + \beta(1-\theta))A^{\theta}} - \frac{\gamma(1+\alpha) + \beta(1-\theta)}{\gamma + \beta(1-\theta)}N_s \tag{2.27}$$

where $A = \frac{\theta}{\alpha(1-\theta)}\frac{c_s}{w_x}$. Input level X also represents the function of shared labor N_s as:

$$
\begin{aligned}
X &= \frac{\theta}{\alpha(1-\theta)} \frac{c_s}{w_x}(N_f + (1+\alpha)N_s) \\
&= A\left(\frac{\beta(1-\theta)}{\gamma+\beta(1-\theta)}\overline{N} + \frac{\gamma(1+r)B}{(\gamma+\beta(1-\theta))A^{\theta}} + \frac{\alpha\beta(1-\theta)}{\gamma+\beta(1-\theta)}N_s\right)
\end{aligned} \tag{2.28}
$$

By substituting equations (2.27) and (2.28) into the equation (2.24), the optimal shared labor N_s^* is expressed as:

$$
\begin{aligned}
N_s^* = &\frac{\gamma+\beta(1-\theta)}{1+\beta+\gamma}\frac{\overline{M}+B}{c_s} + \frac{(\gamma+\beta(1-\theta))(1+r)B}{(1+\gamma+\beta)\alpha\beta(1-\theta)}\left[\frac{\alpha(1-\theta)}{\theta}\frac{w_x}{c_s}\right]^{\theta} \\
&- \frac{1+\beta\theta}{\alpha(1+\gamma+\beta)}\overline{N} - \frac{\gamma(1+r)(1+\beta\theta)}{(1+\gamma+\beta)\alpha\beta(1-\theta)}B
\end{aligned} \tag{2.29}
$$

Additionally, the optimal family labor and input are:

$$
\begin{aligned}
N_f^* = &\frac{\alpha\beta(1-\theta)(1+\gamma+\beta) + (1+\beta\theta)[\gamma(1+\alpha)+\beta(1-\theta)}{\alpha[\gamma+\beta(1-\theta)(1+\gamma+\beta)]}\overline{N} \\
&+ \left[\frac{\gamma}{\gamma+\beta(1-\theta)} - \frac{\gamma(1+\alpha)+\beta(1-\theta)}{(1+\gamma+\beta)\alpha\beta(1-\theta)}\right]\left(\frac{\alpha(1-\theta)w_x}{\theta c_s}\right)^{\theta}(1+r)B \\
&- \frac{\gamma(1+\alpha)+\beta(1-\theta)}{1+\beta+\gamma}\frac{\overline{M}+B}{c_s} + \frac{\gamma(1+\beta\theta)[\gamma(1+\alpha)+\beta(1-\theta)](1+r)B}{\alpha\beta(1+\gamma+\beta)(1-\theta)(\gamma+\beta(1-\theta))}
\end{aligned} \tag{2.30}
$$

$$
\begin{aligned}
X^* = &\frac{\theta c_s}{\gamma+\beta(1-\theta)}\frac{\overline{N}}{w_x} + \frac{\gamma(1+r)B}{\gamma+\beta(1-\theta)}\left(\frac{\alpha(1-\theta)}{\theta}\frac{w_x}{c_s}\right)^{\theta-1} \\
&+ \frac{\alpha\beta(1-\theta)}{1+\beta+\gamma}\frac{\overline{M}+B}{c_s} + \frac{(1+r)B}{1+\beta+\gamma}\left[\frac{\alpha(1-\theta)}{\theta}\frac{w_x}{c_s}\right]^{\theta} \\
&- \frac{\alpha\beta(1-\theta)(1+\alpha\beta)}{\alpha(\gamma+\beta(1-\theta)(1+\gamma+\beta)}\overline{N} - \frac{\alpha\beta(1+\alpha\beta)(1-\theta)\gamma(1+r)}{(1+\gamma+\beta)(\gamma+\beta(1-\theta))}B
\end{aligned} \tag{2.31}
$$

Comparative Statics

The optimal labor and input allocation responses of the household to changes in amount borrowed are represented by the equations (2.32) to (2.34). If a household borrows more than it did previously, it supplies more shared labor, and the family labor supply change is ambiguous. A household also purchases more agricultural inputs if it can borrow more from the microcredit institution. Because the household can change its leisure, changes in family labor depend upon the relative costs of labor sharing, interest rates, and discount rates.

$$\frac{\partial N_s^*}{\partial B} = \frac{\gamma+\beta(1-\theta)}{1+\beta+\gamma}\frac{1}{c_s} + \frac{(\gamma+\beta(1-\theta))(1+r)}{(1+\gamma+\beta)\alpha\beta(1-\theta)}\left[\frac{\alpha(1-\theta)}{\theta}\frac{w_x}{c_s}\right]^{\theta} - \frac{\gamma(1+r)(1+\beta\theta)}{(1+\gamma+\beta)\alpha\beta(1-\theta)} > 0 \tag{2.32}$$

$$\begin{aligned}\frac{\partial N_f^*}{\partial B} = &\left[\frac{\gamma}{\gamma+\beta(1-\theta)} - \frac{\gamma(1+\alpha)+\beta(1-\theta)}{(1+\gamma+\beta)\alpha\beta(1-\theta)}\right]\left(\frac{\alpha(1-\theta)w_x}{\theta c_s}\right)^{\theta}(1+r)\\ &- \frac{\gamma(1+\alpha)+\beta(1-\theta)}{1+\beta+\gamma}\frac{1}{c_s} + \frac{\gamma(1+\beta\theta)[\gamma(1+\alpha)+\beta(1-\theta)](1+r)}{\alpha\beta(1+\gamma+\beta)(1-\theta)(\gamma+\beta(1-\theta))}\end{aligned} \tag{2.33}$$

$$\begin{aligned}\frac{\partial X^*}{\partial B} = &\frac{\gamma(1+r)}{\gamma+\beta(1-\theta)}\left(\frac{\alpha(1-\theta)}{\theta}\frac{w_x}{c_s}\right)^{\theta-1} + \frac{\alpha\beta(1-\theta)}{1+\beta+\gamma}\frac{1}{c_s} + \frac{(1+r)}{1+\beta+\gamma}\left[\frac{\alpha(1-\theta)}{\theta}\frac{w_x}{c_s}\right]^{\theta}\\ &- \frac{\alpha\beta(1+\alpha\beta)(1-\theta)\gamma(1+r)}{(1+\gamma+\beta)(\gamma+\beta(1-\theta))} > 0\end{aligned} \tag{2.34}$$

The way a household's labor and input supply changes relative to changes to the interest rate has the same results as in the basic model. Once the microcredit loan reduces the interest rates charged to the household, the household decreases its optimal labor sharing and input supply. However, comparative statics of family labor remains ambiguous regarding the interest rate changes, because a household can choose between family labor allocation and leisure. Family labor depends on the discount rate of $\gamma = \frac{\Gamma}{1-\Gamma}$. As the $\gamma \to 1$, equation (2.33) becomes negative, because $\frac{\gamma}{\gamma+\beta(1-\theta)} - \frac{\gamma(1+\alpha)+\beta(1-\theta)}{(1+\gamma+\beta)\alpha\beta(1-\theta)} < 0$. This means that the household reduces family labor days if its valuation of leisure increases.

$$\frac{\partial N_s^*}{\partial r} = \frac{(\gamma+\beta(1-\theta))}{(1+\gamma+\beta)\alpha\beta(1-\theta)}\left[\frac{\alpha(1-\theta)}{\theta}\frac{w_x}{c_s}\right]^{\theta} B - \frac{\gamma(1+\beta\theta)}{(1+\gamma+\beta)\alpha\beta(1-\theta)} B > 0 \tag{2.35}$$

$$\begin{aligned}\frac{\partial N_f^*}{\partial r} &= \left[\frac{\gamma}{\gamma+\beta(1-\theta)} - \frac{\gamma(1+\alpha)+\beta(1-\theta)}{(1+\gamma+\beta)\alpha\beta(1-\theta)}\right]\left(\frac{\alpha(1-\theta)w_x}{\theta c_s}\right)^{\theta} B \\ &+ \frac{\gamma(1+\beta\theta)[\gamma(1+\alpha)+\beta(1-\theta)]}{\alpha\beta(1+\gamma+\beta)(1-\theta)(\gamma+\beta(1-\theta))} B\end{aligned} \tag{2.36}$$

$$\begin{aligned}\frac{\partial X^*}{\partial r} &= \frac{\gamma}{\gamma+\beta(1-\theta)}\left(\frac{\alpha(1-\theta)}{\theta}\frac{w_x}{c_s}\right)^{\theta-1} B + \frac{1}{1+\beta+\gamma}\left[\frac{\alpha(1-\theta)}{\theta}\frac{w_x}{c_s}\right]^{\theta} B \\ &- \frac{\alpha\beta(1+\alpha\beta)(1-\theta)\gamma}{(1+\gamma+\beta)(\gamma+\beta(1-\theta))} B > 0\end{aligned} \tag{2.37}$$

The results of labor sharing and input supply in the extended model are consistent with a basic model that does not model the choice of leisure. Agricultural households decrease their labor sharing and input expenditure to increase farm productivity once they receive microcredit loans at reduced interest rates. A household increases its family labor level to pay back the loan credit in the second period. However, in the extended model, this is ambiguous, because family labor and leisure are interchangeable.

If the network effect, α, is high enough, then the labor days and input purchases do not respond to the microcredit loan. High network effect in equations (2.32) and (2.35) reduces the impact of loan size and interest rates on the shared labor supply. Likewise, family labor supply and input expenditures in equations (2.33), (2.34), (2.36), and (2.37) have smaller impacts of loan size and interest rates if the labor sharing network has high network externalities. Whether or not leisure is considered, households are more reluctant to reallocate their labor and input expenditure if the network effect is high. On the other hand, a smaller assumed network effect stimulates households to reallocate their labor or input expenditure in response to the availability of credit.

2.4 Discussion and conclusion

In this chapter, we examined how the choice to participate in labor sharing groups changes with alternatives to borrowing conditions. Using the two-period model with liquidity constraint, our results imply several key findings. First, farmers increase labor sharing and input expenditure if the loan size increases. When the loan size increases, disposable income in the first period also increases, which the household must pay back in the second period. For this reason, a household increases its productivity by investing more inputs and supplying more labor sharing to increase the consumption level in the second period. A household in the two-period model smooths its consumption by substituting its labor from family to sharing group.

Second, decreasing interest rate does not increase labor sharing supply and input expenditure. Instead, the household decreases its labor sharing arrangements and input purchases. Although there remains a debate regarding interest rates, the purpose of microcredit is to provide loans at reduced interest rates compared to money lenders or other informal institutions. For this reason, this chapter assumed that interest rate decreases if the household borrows from a microcredit institution.

Furthermore, the size of the network effect α influences the degree of changes to labor supply and input expenditure. If the network effect is high enough, households respond less strongly to microcredit loan policy, even if the policy increases the amount borrowed or introduces advantageous lower interest rates. Households with lower network effects are more sensitive to their labor and input changes as the policy is implemented. Thus, theory suggests that a null empirical relationship between microcredit availability and labor sharing is indicative of strong network synergies in labor sharing groups.

Two different effects emerge as the interest rate decreases. Due to the advantages of lower interest rates, the household's repayment in the second period reduces if they receive a loan from the microcredit institution, assuming the loan size remains unchanged. For this reason, disposable income increases in the second period, which leads a household to decrease its allocation of labor sharing and inputs. In the first period, a household also consumes more after reducing its expenditure. This income effect occurs after the interest rate has decreased.

Family labor and shared labor substitute for each other in response to microcredit loan size and interest rate changes. The household's labor sharing in our study is reciprocal, and reduction of labor supply also decreases the household's labor sharing demand. As a result, shared labor supplied in the farm decreases if the household receives a microcredit loan. Farmers instead increase family labor to maintain the farm productivity level. The theoretical model in this study imposes perfect symmetry in shared labor supply between share-in and -out. For this reason, the household's labor sharing demand decreases as the supply decreases.

If a household can choose to allocate its time in leisure, farmers' responses to the interest rate reduction on family labor depend on their preferences regarding leisure. The household's utility maximization can be achieved by either increasing consumption or increasing leisure. For this reason, farmers can choose between increasing consumption or increasing leisure once they have benefited from lower interest rates.

Note that the results in the theoretical framework assume the output, input, and credit markets are complete, and that the household's utility and profit maximization are not influenced by other unobserved factors except exogenous factors and liquidity constraints introduced in the model. In the complete market case, a household optimizes its labor and input level and maximizes the utility level. However, imperfect market conditions restrict the household's optimal labor or input choices. As a result, household utility might be sub-optimal, which is common in developing countries. In the real world, farmers with more experience in labor sharing arrangements do not retain redundant labor in the group and inefficient neighbors will be excluded from the group. If this is the case, the household's labor sharing participation is at the most efficient level because inefficiency from anyone within the group is seldom. Empirical analysis using the Ethiopia Rural Household Survey is implemented in Chapter 3 to examine the theoretical results in the case that the network effect influences the household to be reluctant to change its labor demand and supply.

The study has several limitations. First, we only considered labor sharing to be reciprocal, with farmers exchanging their labor. However, some farmers in developing countries also utilize labor supply arrangements such as festive labor, which does not require perfectly symmetric reciprocity. If labor sharing is not necessarily reciprocal, then the household's supply decision regarding labor sharing becomes asymmetric. It is then possible to explain the labor sharing supply and demand relationship more clearly.

Second, this study does not consider the outside labor market, which is also common in developing countries. However, in this case, farmers' labor allocation decisions will change to reflect the household's ability to supply its labor on off-farm jobs. Although previous studies regarding the effect of microcredit (Tarozzi et al., 2015) show there are no significant time changes allocated on outside jobs, wages earned from off-farm activities increased, which indicates the existence of the labor market. For this reason, labor market availability and allowance of labor hiring in the theoretical model might change the optimal labor allocation and comparative statics.

Third, this study considered both interest rates and loan amounts to be exogenous. However, loan amounts in some cases might be endogenous, and it is possible for households to increase their amount borrowed once interest rates decrease. Further studies might consider the loan size to be endogenous to explain the effect of interest rates.

Chapter 3

An empirical analysis of the effect of microcredit on informal labor sharing in Ethiopia

3.1 Introduction

Informal social arrangements commonly arise in developing countries as a method of coping with existing market inefficiencies, allowing households to receive the benefits of positive network effects and mutual insurance arrangements. Labor sharing represents one such informal social arrangement, as farmers exchange agricultural labor on one another's land. Labor sharing is particularly attractive to households when farming practices are highly labor intensive and time sensitive.

These conditions apply to Ethiopia, where agricultural mechanization rates are low and labor demand during peak season is high. Smallholder farmers therefore commonly participate in labor sharing networks for weeding, harvesting, and post-harvesting activities (Bachewe et al., 2016; Mekonnen and Dorfman, 2017). Agricultural economists studying these networks, both in Ethiopia and elsewhere, have described the positive network synergies of enhanced productivity that result from organizing farm labor into team-based tasks (Gilligan, 2004; Krishnan and Sciubba, 2009; Mekonnen and Dorfman, 2017).

Aside from the productivity enhancing elements of labor sharing arrangements, Moore (1975) described an alternative explanation for the popularity and persistence of labor sharing: liquidity constraints. Limited working capital precludes the possibility of hiring wage labor, which forces households into these alternative arrangements. For this reason, relaxing liquidity constraints leads farmers to participate in the labor market actively, which gradually decreases demand for labor sharing.

This study empirically examines whether increases in microcredit loans impact the prevalence of household demand for labor sharing arrangements in Ethiopia.

We find that microcredit loans have no effect on labor sharing arrangements. Microcredit loans also have no impacts on family and hired labor supply. The results of the study indicate that households do not change the structure of labor supply even if working capital increases. Notably, our results differ from Moore (1975)'s argument that illiquidity is one reason for labor sharing arrangements. Labor sharing in Ethiopia is prevalent not because of liquidity constraints but possibly due to positive network synergies. Previous studies by Gilligan (2004) and Mekonnen and Dorfman (2017) are consistent with our results regarding network synergies of labor sharing. Another potential explanation of these results is that microcredit loan-takers cannot easily change labor sharing arrangements. Labor sharing arrangements require mutual agreement, and it is difficult to change the size of the labor sharing group even if the microcredit beneficiary has incentives to change its labor supply.

The results also show that microcredit loans increase farmers' input expenditures, which impacts farm productivity. Due to low working capital, households in Sub-Saharan African countries tend to purchase fertilizer at rates lower than the required level. For this reason, microcredit loans encourage farmers to supply more fertilizer on their farms. The results from Ethiopia are consistent with this story.

Effects of other credit services on shared labor supply differ from the effects of microcredit loans. Network loans stimulate households to supply more labor in the labor sharing group relative to non-recipients. In village networks, farmers have incentives to participate in network activity due to the increased probability of receiving loans. For this reason, farmers are motivated to work more in labor sharing groups to receive loans. This positive relationship between network loans and labor sharing days also suggests that social ties, peer pressure, and the reputation mechanism may force farmers to supply more labor in the labor sharing group once they receive network loans.

The results of the study indicate that fertilizer credit program recipients are less likely to share labor with their neighbors. The negative relationship is driven by the lowest income group. However, fertilizer credit users supply more family labor and also purchase more fertilizer inputs relative to non-recipients. The effect of fertilizer credit on input expenditure is similar to microcredit loan effects, which indicates that microcredit users purchase fertilizer inputs once they receive loans.

One potential implication of the study's results is that microcredit loans might benefit households that involuntarily engage in labor sharing networks after taking village loans. If households could instead receive loan services from microcredit institutions, they might supply labor in the sharing network efficiently rather than excessively.

This study contributes to several strands of research regarding labor sharing. First, unlike Moore (1975)'s prediction, we show that labor sharing is prevalent even though liquidity constraints are relaxed. Our results show that labor sharing in Ethiopia does not decrease even if households receive microcredit loans, which implies that illiquidity is not the only reason for households to maintain labor sharing relationships.

Second, this study identifies the heterogeneity of loan effects among different credit sources such as microcredit loans, network loans, and fertilizer credit programs. Despite the fact that credit services increase households' working capital, the actual labor responses of households are different. This study also discusses the reasoning for these responses, as well as policy implications for the heterogeneity of household labor sharing supply.

This chapter is organized as follows: Section 3.2 presents a literature review of rural labor and microcredit in Ethiopia; Section 3.3 and Section 3.4 detail the data summary and empirical model; Section 3.5 compiles the results and discussion of results; Section 3.6 examines the robustness of the model; and Section 3.7 offers a conclusion.

3.2 Literature review

3.2.1 Rural labor in Ethiopia

The majority of villagers in rural Ethiopia gain income by participating in crop cultivation and livestock rearing (Bachewe et al., 2016). Reardon et al. (2007) found that off-farm income represents less than 20% of the share of the total income in Ethiopia, which is below the average of Sub-Saharan Africa.[1] Accordingly, income from agriculture is crucial, and farmers must meet the high demand for on-farm labor from outside of the household to increase their own on-farm income and reduce the seasonal labor deficiency.

Interpersonal relationships and reciprocal sharing in developing countries are prevalent (Fafchamps and Gubert, 2007). In addition to labor sharing groups, Ethiopia has sharing networks, including the saving group *iqub*; working groups, such as *jige, wonfel* and *debo*; and the funeral insurance association *idir* (Abebaw and Haile, 2013).

Ethiopian farmers have two major labor sharing mechanisms: *wonfel* and *debo*. *wonfel* and *debo* are small labor sharing groups that are arranged before the agricultural season starts. While *wonfel* is a bilateral labor exchange between farmers, *debo* is a festive labor exchange in which a hosting person provides drinks and music to laborers. In the *wonfel* arrangement, the hosting person does not necessarily provide any food or drinks to laborers, but they compensate laborers by reciprocating labor. For this reason, *wonfel* is a more clustered and homogeneous small group, while the *debo* group is a bigger group with a heterogeneous composition of farmers (Krishnan and Sciubba, 2009).

Since labor sharing groups work together for several days during the farming season, social learning and technology adoption from their peers is possible. Wossen et al. (2015) determined that an Ethiopian household that is part of a labor sharing group is more likely to adopt land management practices. However, Mekonnen and Dorfman (2017) found that the learning effect does not necessarily occur. Labor sharing groups are arranged by season,

[1] Although the majority of Ethiopian youth living in rural areas (Bezu and Holden, 2014) face high unemployment rates, it should be noted that rural wage level is gradually increasing, which lowers employment rates in the off-farm sector (Bachewe et al., 2016).

and this time period is not enough for the transition of information or learning technology from one individual to another.

Labor sharing has a positive effect on teamwork (Gilligan, 2004), as it increases network synergies (Mekonnen and Dorfman, 2017) and enhances productivity through the networking effect (Krishnan and Sciubba, 2009). Perhaps, for this reason, labor sharing in Ethiopia is still commonly practiced among villagers. In contrast to the positive aspects of labor sharing, Park (2019) showed that working with friends decreases productivity if friends working in the same manufacturing plant are close enough to socialize. Park (2019) suggests that labor productivity has negative network effects if workers do not have labor sharing relationship and socialize each other.

Labor sharing in Ethiopia is common, and shared labor exceeds hired labor for average labor days in the case of teff farmers (Bachewe et al., 2016). Furthermore, the proportion of labor sharing for harvesting and post-harvesting activities is more than 25%, which shows that labor sharing is important for households to maintain high productivity and income levels. Households in Ethiopia also share labor if they are more isolated from urban areas such as Addis Ababa and if there is no labor market for waged jobs. Bachewe et al. (2016) reported that accessibility to urban areas and commercialization increases labor hiring, which means that households' labor arrangements are significantly influenced by market accessibility. Little (2008) showed that there are no differences in labor sharing between food recipient and non-recipient groups, suggesting that household consumption level is not related to the labor sharing arrangement.

Erasmus (1956) and Moore (1975) suggested that labor sharing is bilateral and reciprocal.[2] Most anthropologists view reciprocity as one of the primary motivations for labor sharing.[3] In agriculture-dominant regions, return to labor matters. For example, timing of

[2] Moore (1975) defined labor sharing as co-operative labor, or the "...joint performance of a task, or a series of sequentially-related tasks, by a group of persons practicing a minimal division of labour whose relationship to the beneficiary, or beneficiaries, of their work is other than that of employer to employee...." This definition includes reciprocal labor, traditional working groups, and festive labor.

[3] Reciprocal altruism occurs when each farm household encounters labor shortage repeatedly and other households provide assistance to one another. In this situation, the benefit from assistance is always more than the cost of assistance given (Macfarlan et al., 2012).

planting and harvest drives farmers to work as a team (Gilligan, 2004), while network synergies from networking increase farm productivity (Krishnan and Sciubba, 2009). Labor sharing also decreases transaction costs if households lease machinery and use it together (Artz et al., 2010).

3.2.2 Microcredit in Ethiopia

Financial inclusion in Ethiopia is still low compared to its economic growth (Zwedu, 2014). Private financing and microcredit were introduced in Ethiopia in the late 1990s. In 1996, proclamation no. 40/1996 authorized the establishment of microcredit institutions and private insurance companies (Amha and Narayana, 2000; Gobezie, 2005; Meagher, 2002; Zwedu, 2014), which stimulated the spread of microfinance institutions nationwide in rural and urban Ethiopia. Since then, the number of microfinance institutions in Ethiopia has increased from 16 in 1999 to 38 in 2018 (National Bank of Ethiopia, 2019). The number of loan-takers per each microcredit institution averages approximately 86,000 individuals, making Ethiopians the second-biggest group of loan-takers among the 10 largest Sub-Saharan African countries (Wassie et al., 2019).

Around 35% of Ethiopian households received financial services from formal institution between 2015 and 2016, and most of these households patronized either public banking or microfinance institutions (World Bank, 2016). The World Bank Living Standard Measurement Survey (LSMS) also reported that around 28% of households have an account in microfinance institutions, which means that microfinance institutions have twice as many account holders as private banks. However, lending from informal institutions separate from formal banks or microcredit institutions still accounts for 80% of total loans, and these borrowers take loans at significantly higher interest rates (Demirguc-Kunt et al., 2018). Microfinance institutions are located mostly in major regions such as Amhara, Oromia, and Tigray (Central Statistical Agency of Ethiopia), which restricts account holders in isolated regions from seeking the relative benefits of microcredit institutions.

Studies on the effect of microcredit loans in Ethiopia have examined whether relaxing liquidity constraints influences a household's income, production, labor allocation, and livelihood.[4] As Bedemo et al. (2013) explained, liquidity constraints also influence the household's on-farm labor allocation and prevent labor-intensive farming, which decreases productivity. Previous studies related to microcredit accessibility explained household on-farm labor supply increases (for example, Tarozzi et al. (2015) in Ethiopia and Crépon et al. (2015) in Morocco). Fink et al. (2018) showed that relaxing liquidity constraints increases a household's demand for hiring daily-wage workers, which increases agricultural outputs.

Microcredit also has effects on agricultural production (Belwal et al., 2012), livelihood (Berhane and Gardebroek, 2011; Diro and Regasa, 2014), and poverty reduction (Mamaw et al., 2018) in Ethiopia. Microcredit in northern Ethiopia has influenced household consumption levels (Berhane and Gardebroek, 2011). However, Berhane and Gardebroek (2011)'s results suggested that a loan only increases the household's consumption level if the household can borrow from the microcredit institution multiple times rather than once. Their result suggested that it takes time for the household to exhibit the welfare effect because a one-time loan has a lower probability of improving livelihood. Similarly, Siyoum et al. (2012) argued that a household's initial wealth level influences the effects of microcredit loans on poverty reduction and food insecurity.

In contrast to the positive effects outlined above, some studies have found that microcredit loans do not always have the anticipated effect. For example, Tarozzi et al.'s (2015) study covering rural Amhara and Oromia between 2003 and 2006 did not find any evidence of economic improvements for loan takers, despite the fact that borrowing rate increased rapidly. However, their study suggested that the introduction of microcredit in rural Ethiopia increases agricultural input expenditure even though it does not necessarily increase farm revenue.

[4] For example, *American Economic Journal: Applied Economics* published an edition in 2015 that discussed the effect of microcredit in six countries including Ethiopia.

3.3 Data and summary

The analysis in this study relies on data collected by the Ethiopia Rural Household Surveys (ERHS). The panel survey is a collaboration between several institutions, such as the International Food Policy Research Institute (IFPRI), Addis Ababa University, the Center for the Study of African Economies, and the University of Oxford. In total, 7 survey rounds of the ERHS have been conducted between 1989 and 2000.

Out of all the aforementioned data sets, three surveys, including the 5th (1999), 6th (2004) and 7th (2009) data sets, provide consistent data for studying labor sharing networks and microcredit loan participation. The ERHS survey was conducted in 4 major regions: Amhara, Oromia, SNNPR, and Tigray. The number of households studied in the initial rounds of the 1999, 2004, and 2009 surveys were 1,681, 1,327, and 1,577 in 15 peasant associations (PAs), respectively. [5] We included households in our study only if they were surveyed in at least two panel rounds.

The purpose of this study is to examine households' on-farm labor demands for family, shared, and hired workers. For this reason, households that remained landless for all survey rounds between 1999 and 2009 were excluded from the study. Additionally, 150 households surveyed in the 6th round had no recorded personal information regarding the head of household's age, education level, or gender. For this reason, these households were also excluded from the study. As a result, the final numbers of households surveyed were: 1,329, 1,007, and 1,285 in each survey round.

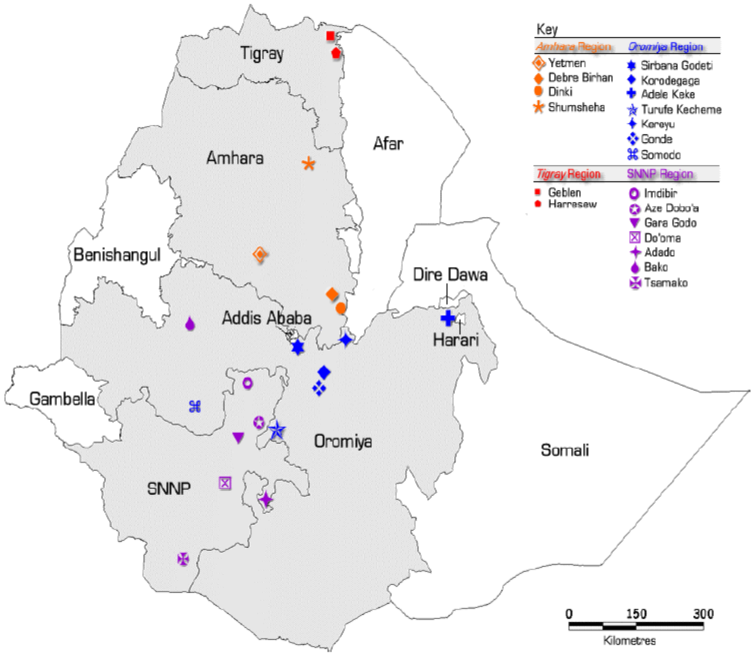
As shown in Figure 3.1, the ERHS survey covers the central, southern, and northern regions of Ethiopia where most of the population resides.

The ERHS survey includes microcredit loan information. In this study, microcredit includes loans from microcredit institutions and NGO credit services. Microcredit loan recipients in Ethiopia made up approximately 3 % of the total population in 1999. Figure 3.2 shows the trends associated with all types of loans, including microcredit loans, borrowing from village credit networks, money lenders, and fertilizer programs.[6] Most of the loan

[5] The peasant association, which is called *Kebele* in Ethiopia, represents the lowest administrative level.

[6] These loan networks include *Equb*, *iddir*, cooperatives, and local organizations other than the govern-

Figure 3.1: *Locations of PA(kebele)s included in the ERHS Survey*



Source: Ethiopian Rural Household Survey

borrowers who selected the option "others" on the survey received loans from central or local governments.

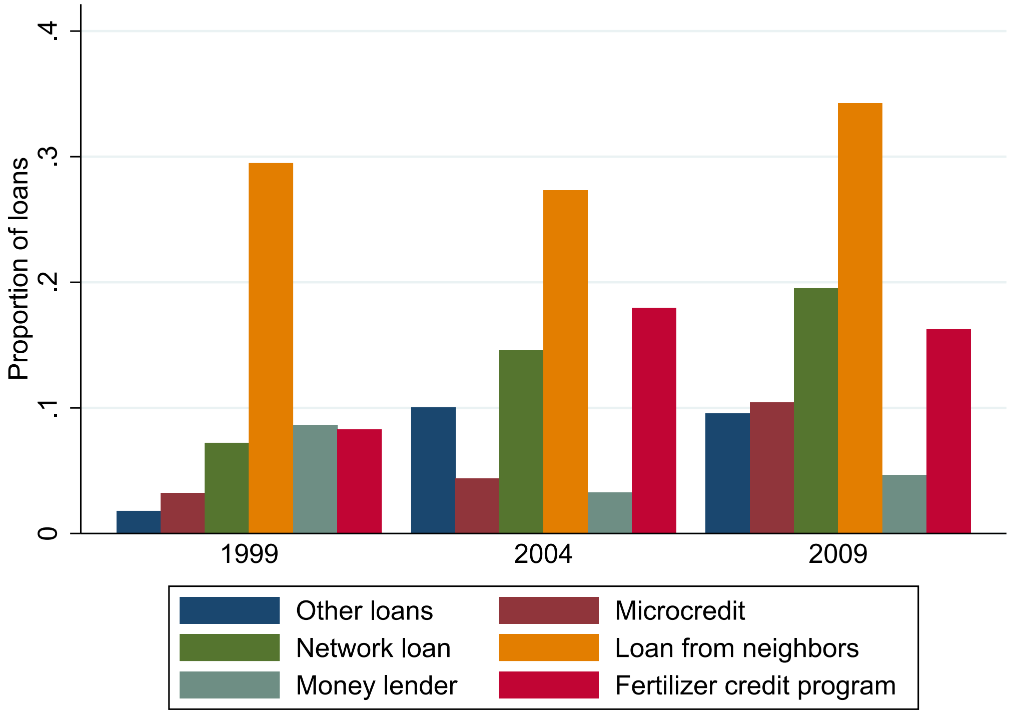
The proportion of households taking loans from microcredit institutions and village networks gradually increased during the years from 1999 to 2009. Although the Ethiopian government announced the launch of microcredit in 1996, preparations for private credit institutions to enter the microcredit market lagged. Accordingly, actual recipients of microcredit in the 4 regions listed in the ERHS survey accounted for around 3% of the population surveyed. Loan recipient rates began to increase after 1999, reaching approximately 10% in 2009. Increased density of microcredit loan beneficiaries was mostly led by the Haresaw kebele in 1999 and 2004.

Apart from microcredit services, fertilizer credit programs were also implemented in Ethiopia. Accordingly, farmers in the survey area are benefitted by the fertilizer credit program.[7] The proportion of households receiving benefits from the fertilizer credit program

ment. Saving groups such as SACCO were excluded because this study included loans from the village network only if the household surveyed borrowed from such networks.

[7]The fertilizer credit program in Ethiopia is supported by the Ethiopian government. Farmers acquire

Figure 3.2: *Trend of loan recipients*



Source: Ethiopian Rural Household Survey

increased between the years 1999 and 2004. As of 2004, around 14 percent of the population surveyed were fertilizer credit program recipients, although the proportion of beneficiaries decreased during the years 2004 to 2009.[8]

Over 3 survey rounds from 1999 to 2009, around 6 percent of households on average benefited from microcredit loans. At the same time, around 14 percent of households also received loans from informal networks. The pattern in figure 3.2 shows that both microcredit loans and network loans in Ethiopia increased in 2009. The proportion of households receiving credit services also increased smoothly due to microcredit and network loans.

Microcredit loan recipients originated from 8 PAs in 1999, and the overall average of microcredit loan recipients consisted of only 3 percent of the population surveyed (table 3.1). Microcredit loans were not prevalent until 2004, and most loan takers were located in the

fertilizer based on credit and repay it after the harvest season (Getnet et al., 2005).

[8]In 2005, international donors such as World Bank and IMF realized the importance of the private sector to the agricultural input markets for seeds and fertilizer. Accordingly, the shift in policy was intended to make the private input market more competitive (Dom, 2009).

Korodegaga kebele in Oromia region and the Haresaw kebele in Tigray region. Microcredit loans were later introduced to approximately half of PAs between the years 2004 and 2009. In that same year, the number of microcredit recipients increased in most PAs, and more than 20% of the populations of some villages were loan beneficiaries. As a result, the proportion of microcredit recipients doubled between 2004 and 2009, reflecting the spread of microcredit loan services by credit institutions and NGOs.

Microcredit in the Haresaw kebele was more prevalent (25% of villagers received microcredit loans in both the 1999 and 2004 survey rounds) in 1999 compared to other villages. Since the purpose of this study is to examine the effect of microcredit benefits on the labor demand across the years, the Haresaw kebele was excluded for the robustness check.

The trend of microcredit participation in Ethiopia shows that microcredit loan access has expanded across all regions, and beneficiaries of microcredit loans have increased. Table B.2 reports that the proportion of microcredit recipients among villages with at least one borrower increased from the 1999/2004 to 2009 rounds. Haresaw kebele is the only PA in which the proportion of microcredit recipients decreased in 2009 compared to 1999 and 2004.

Among all credit services used (microcredit, network loan, and fertilizer credit), microcredit accounted for the highest average number of loans. Table B.1 reports the average amount by different sources. The amount borrowed from microcredit institutions increased from 45.5 birr ($3.15) in 1999 to 214.4 birr ($14.88) in 2009. Network loan amount borrowed increased from 39.4 birr ($2.73) in 1999 to 57 birr ($3.96) in 2009.[9] The amount of fertilizer credit provided to farmers also gradually increased. The average amount provided by the fertilizer credit program increased from 18.2 birr ($1.26) in 1999 to 178 birr ($12.35) in 2009. Considering only the loan recipients, the average loan size of microcredit, network loan, and fertilizer credit services change from 1,439.7 birr ($99.91), 556.7 birr ($38.63), and 621.3 birr ($43.12) in 1999 to 2,055.8 birr ($142.66), 481.2 birr ($33.39), and 1,174.6 birr ($81.51) in 2009 each (table B.1). The average loan size of microcredit and fertilizer credit services for each recipients has been increased between 1999 and 2009.

[9] Loan amounts are inflation adjusted value based on 2010. According to the World Bank, exchange rate of Ethiopian local currency in 2010 is approximately 14.41 birr per US dollar respectively.

Microcredit loan services benefited households regardless of income level. Across all survey rounds, by income quantile, microcredit recipients consisted of 6%, 7%, 5%, and 8% of the population surveyed from the lowest to the highest income group, respectively. Network loan percentages by income quantile represented 16.5%, 13.7%, 12.2%, and 8.5% from the lowest to the highest income group, respectively. Furthermore, the fertilizer credit amounts for the highest 25% income group was approximately 38% greater than that of the lowest income groups.

Loan-taking from money lenders and neighbors decreased in Ethiopia from 1999 to 2004. For example, the proportion of households taking loans from either money lenders or neighbors decreased, which indicates borrowers switched from informal to formal sources. Even though loan-taking from money lenders increased by around 1% in 2009, it made up the lowest percent of loan recipients among all loan sources, suggesting a credit transition from money lender to microcredit and villager network loans. Borrowing from neighbors, friends, and relatives decreased from 29% to 27% between 1999 and 2004, although it remained the most important source of urgent borrowing. In 2009, borrowing from neighbors increased to 34.2%. However, the proportions of all other loan sources also increased between 2004 to 2009, which indicates that both informal and formal credit markets expanded and villagers in Ethiopia took out loans more frequently than in previous years. Other loans from formal banks or governments also increased from 1999 to 2009, demonstrating the diversification of loan sources.

The loan transitions across rounds suggest that households in Ethiopia shifted from informal credit sources to formal credit sources (table 3.3). The first table in table 3.3 includes the 1,124 households that were surveyed in all 3 rounds. The second panel in table 3.3 includes households surveyed either in the 1999 or 2004 round and also in the 2009 round. Because microcredit trends in table 3.1 indicate that the proportion of households that borrowed from microcredit institutions increased greatly in the 2009 round, it is important to compare the proportion of households that received loans in the 1999/2004 rounds to those in the 2009 round. Comparing the 1999/2004 rounds and the 2009 round is also beneficial because some villages did not record information about their populations' loan portfolios in either the 1999 or 2004 round. Loan information of some villages is missing because these PAs were not included in the survey in the 2004 round.

Most of the households that received loans from money lenders in 1999 did not continue to use a money lender in either in 2004 or in 2009. This is clearer if we look at the second panel in table 3.3, which indicates that 91% of those who borrowed from a money lender in 1999 or 2004 did not do so in 2009. Of those who previously borrowed from a money lender, less than 30% did so in 2009. Loans from friends and relatives also decreased from 1999 to 2004, with around 24% of surveyed households responding that they borrowed from those groups either in 1999 or 2004 but not in 2009. At the same time, the proportion of households that received microcredit loans in the 2009 round but not in previous years is 8%, which is evidence of loan transition from informal sources to institutional sources.

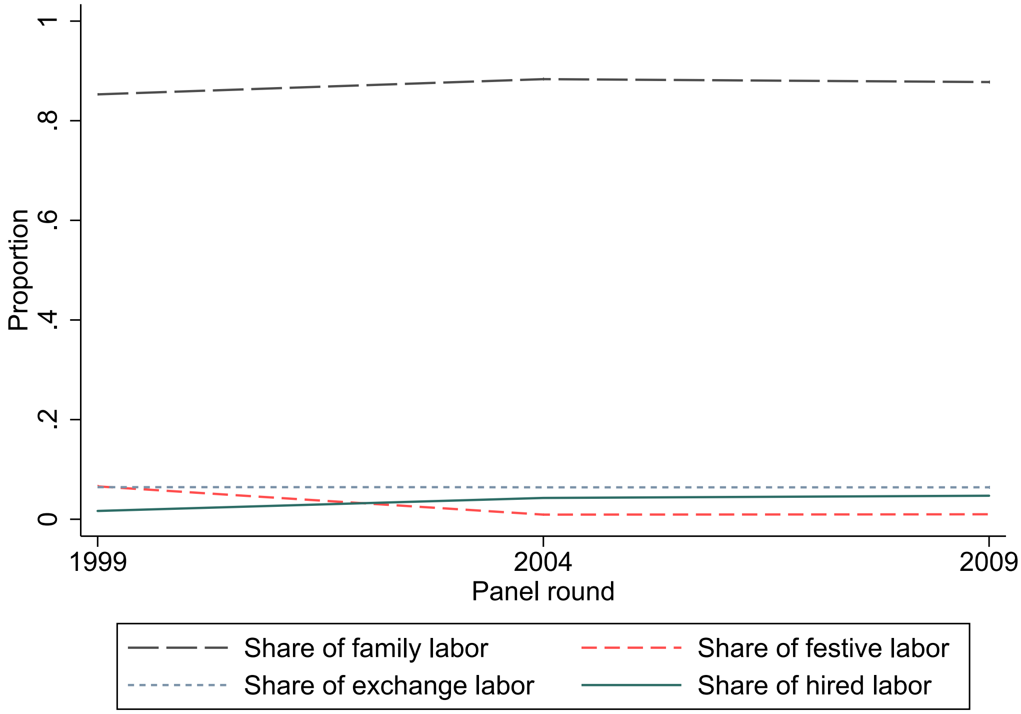
The number of households receiving loans from other sources also increased across survey rounds, which is due to an increase of central and local government loans. 97.8% of the households in the 4 regions surveyed were not eligible to borrow from formal banking systems. The proportion of households receiving loans from local credit sharing networks indicates that use of network loans expanded between 1999 and 2009. The proportion of households that received network loans in either 1999 or 2004 but not in 2009 is similar to the proportion that received loans in 2009 but not in either 1999 or 2004 (10.1% vs. 13.9%). This demonstrates that the proportion of network loan-takers gradually increased by 2009.

In the 10 years between 1999 and 2009, credit sources diversified due to the growth of microcredit and network loan institutions, which has benefited households through increased freedom of credit choice.[10] Since then, households reduced the number of loans taken from either money lenders or friends. For this reason, the proportions of households that did not receive either microcredit or network loans in 1999 but did receive in 2004 or 2009 are 13.3% and 25%, respectively. Additionally, 6.9% of households first received microcredit loans in 2009.

There were no variations of labors across years between family and shared labor. As a

[10] These trends mirror those reported at the national level by Abay et al. (2019) and Mackie et al. (2015), who indicated a steady expansion of microfinance institutions and rural SACCO unions.

Figure 3.3: *Trend of on-farm labor supply*



Source: Ethiopian Rural Household Survey
Notes: Exchange in this context means reciprocal labor exchange. Festive labor indicates that host provides some food and drinks while neighbors voluntarily work for this host for short time.

share of total agricultural labor, reciprocal exchange labor (*wonfel*) remained consistent over the three survey rounds, while the share of festive (*debo*) labor decreased. Figure 3.3 reports the trends of each type of labor.[11] The share of family labor remained largely consistent from 1999 to 2009. Demand for hired labor relative to other labors increased gradually from 1999 to 2009. As previous studies have shown, labor hiring in Ethiopia was relatively low, whereas labor sharing was comparatively higher in all three rounds.

The summary statistics in table 3.2 show that 26 % of households were female-headed. Among the villagers, 75 % were farmers who owned an average of 1.84 hectares of land

[11] Labor days are only calculated for the Meher (i.e., rainy) season due to the high labor force supply relative to the Berg (i.e., dry) season. During the Berg season, Ethiopian farmers rarely cultivate their farmland and the average labor supply of the household is low. 1 day of child labor is considered equivalent to 0.5 days of adult labor. Because several households in Ethiopia have less than 0.01 hectares of the farmland, labor days per hectare are extremely high compared to the other households. For this reason, we winsorized the upper 0.5% of the households, and labor per hectare variables are censored.

to cultivate. The Simpson land fragmentation index was 0.35.[12] The crops were relatively diversified according to the crop diversity index. Crop diversity score was calculated using a Simpson Index and the land size of each crop cultivated. This result indicates that households in Ethiopia cultivate multiple crops together rather than engaging in mono-cropping.

3.4 Empirical model

3.4.1 Estimation strategy

In the following section, we estimate the effect of microcredit on households' supply for family, hired, and shared labor. The conditional labor days of family ($L_{it,f}$), shared ($L_{it,s}$), and hired ($L_{it,h}$) labor are expressed as:

$$L_{it,j} = \beta_{1,j} + \beta_{2,j} X_{it,j} + \beta_{3,j} D_{it,j} + \sigma_{i,j} + \delta_{t,j} + \epsilon_{it,j} \tag{3.1}$$

where the dependent variable $L_{it,j}$ represents the labor days contributed to farm production by the three groups, with the subscript $j = f, s, h$ indicating the form of family, shared, and hired groups. Covariate $X_{it,j}$ is a vector of household characteristics; $D_{it,j}$ is a dummy variable representing the household receiving a microcredit loan; $\sigma_{i,j}$ and $\delta_{t,j}$ are the household and round fixed effects, respectively; and $\epsilon_{it,j}$ is an error term. The subscripts i and t indicate the household and survey round, where $t = \{1999, 2004, 2009\}$.

This estimation includes household fixed effects $\sigma_{i,j}$ for two reasons. First, both the household and village's unobserved heterogeneity influence household labor allocation decisions.

Second, microcredit institutions are not equally distributed across the nation. In Ethiopia, microcredit branches are more likely to be located in central regions such as in Oromia region, which increases the probability of getting loan credits. Furthermore, distance from

[12] Land fragmentation using Simpson index varies from 0 to 1, and a higher index indicates more fragmentation. Simpson index was calculated using $S = 1 - \frac{\sum a_j^2}{A^2}$, where A is total land owned by the household and a_j is the land size of each separate parcel.

the capital city (i.e., Addis Ababa in Ethiopia) influences the household's labor supply decision (Bachewe et al., 2016). Previous studies (Berhane and Gardebroek, 2011; Islam, 2011; Pitt and Khandker, 1998) noted that microcredit selection bias in the panel regression can be controlled through household or village fixed effects, because fixed effect estimation cancels out the unobserved invariant heterogeneity at the relevant level.

The focus of the analysis is estimating the parameter $\beta_{3,j}$, which summarizes the impact of microcredit on the number of days the household utilizes each category j of agricultural labor. Consistent estimation of the causal impacts of microcredit programs can be challenging, especially when mircrocredit access or take-up is not randomly allocated ex-ante (Berhane and Gardebroek, 2011). In particular, nonexperimental analysis carries a potential selection-bias problem (Islam, 2011). For example, microcredit recipients might have better ability or networks that might both make them more likely to take loans from the institution and influence the labor supply and input expenditure by the household. In equation 3.1, such selection bias could arise from unobserved household heterogeneity and would then appear in the error term $\epsilon_{it,j}$. Uncontrolled, the bias would prevent consistent estimation of microcredit impacts. When ex-ante randomization is not feasible, methods to solve this selection bias problem include panel data or quasi-experimental analysis (Berhane and Gardebroek, 2011; Islam, 2011; Nghiem et al., 2012; Pitt and Khandker, 1998). In our model, we use a household fixed effect model that cancels out the unobserved invariant heterogeneity. As a result, the parameter of interest is identified by within-household changes across the panel years.

Possible weaknesses of the fixed effect model is that it assumes the entire selection-bias problem arises from time-invariant heterogeneity (Berhane and Gardebroek, 2011). Accordingly, the fixed effect model does not adequately control for time-varying sources of bias that may simultaneously impact labor allocation and microcredit decisions. In section 3.6, we adopt a matched DID analysis as an alternative to the unmatched fixed effect model (Mazumder and Lu, 2015; Nghiem et al., 2012). We also decompose the panel analysis by year to better understand the dynamics driving the main estimation.

In Ethiopia, social networks are active, and villagers often participate in labor, credit, and funeral groups (*iddir*) together. For this reason, informal credit networks influence the household's labor network participation. Loan recipients from an informal credit network constituted 14% of the total borrowers. We include the informal credit recipient dummy variable as a household characteristic to separate the effects of informal credit and microcredit on the labor sharing changes.

The indicator variable of fertilizer credit program beneficiaries was also included. In Ethiopia, the implementation of several government-led nationwide programs, such as fertilizer credit programs, influenced household labor supply decisions. Ethiopia has a fertilizer credit program that is similar to credit loans. The government of Ethiopia provides farmers fertilizer on credit program (Zerfu and Larson, 2010). For the fertilizer credit services, the government guarantees farmers to take a fertilizer without interest rates, and then farmers pay back after the harvest season (Dercon and Christiaensen, 2011). This unique program in Ethiopia has been evaluated the increase in fertilizer adoption (Matsumoto and Yamano, 2011). Since input and labor are complements each other, it is important to disaggregate impacts of the microcredit program and the fertilizer credit program on household labor demand for family, shared, and hired group.

The effect of microcredit on the labor demand of households also depends on the land size and its distribution. For example, higher land fragmentation increases management costs, forcing households to hire more labor if they cannot monitor the land during the time workers from the outside provide labor. Total arable land size also influences labor sharing decisions in terms of equal reciprocity of labor exchanges (Krishnan and Sciubba, 2009), and we included land fragmentation index and land size as covariates.

The purpose of a loan by the household is not only for agricultural uses, but also for consumption, non-farm business, or urgent needs, such as health and education purposes. For this reason, as a robustness check, we also estimated the equation (3.1) using a microcredit dummy equal to one only if the loan is recorded as for agricultural purposes. Inclusion of the dummy variable of microcredit loan beneficiary for agricultural purposes prevents underestimating the effect of microcredit on labor changes if non-agricultural loans are not relevant for alleviating household liquidity constraints in labor hiring decisions. We compared the results of labor allocation decisions for taking a microcredit loan for all purposes to taking a loan only for the agricultural uses, including fertilizer purchases, livestock purchases, and payment for labor hiring.

Gender differences in credit and labor market participation are common in Ethiopia. For example, labor sharing occurs mostly between men, while women's participation in labor sharing is relatively low. Following Pitt and Khandker (1998), we also disaggregated the gender of borrowers and estimated the effect of microcredit loans separately to analyze the impact on labor supply. If at least one woman took a loan from either an NGO or a microcredit institution, then that household was treated as a woman-borrowing household.

3.5 Results and discussion

3.5.1 Microcredit effects on allocation of farm labor

Microcredit loans do not have an effect on labor sharing decisions. Fixed effect results reported in table 3.4 show that the impact of microcredit on labor sharing is small (0.021) and insignificant (p-value = 0.99). Microcredit loan effects on family labor supply are also statistically insignificant. Despite the fact that microcredit loan users are more likely to purchase fertilizer, households do not supply more family labor to complement input expenditure. Additionally, microcredit loan effects on labor hiring are statistically insignificant (table 3.4, column 3). The null result indicates that microcredit loans also do not influence the daily labor hiring market.

These results are consistent with studies on the persistence of labor sharing that emphasize the productivity of these arrangements rather than liquidity constraints. If liquidity constraints drive farmers to substitute shared and family labor for hired labor, as argued by Moore (1975), microcredit should increase the usage of these labor sources, which was not the case in this study. The null result is instead consistent with Gilligan (2004) and Mekonnen and Dorfman (2017), who argued that network synergies from labor sharing increase farm productivity. In that case, liquidity should have little impact on the decision to enter these arrangements, as found in this study.

An alternative explanation as to why households do not increase labor sharing even if they take out microcredit loans is that only some households within the labor sharing group receive microcredit loans and other households do not have motivations to increase labor supply in the group. For this reason, microcredit loan recipients cannot change their labor supply, even if they want to do so.

On the other hand, household labor sharing group size could potentially already be at the efficient level. If so, an increase in the labor sharing group size could result in a labor allocation inefficiency. For this reason, households with more working capital would not choose to increase their labor sharing supply.[13]

The failure to identify a positive effect of microcredit on labor hiring may be a symptom of a broader concern regarding labor market failure in Ethiopia. In general, imperfect labor markets give rise to the non-separable decision problem that is the hallmark of agricultural household models. Under these conditions, households' family labor usage should directly depend on family composition. Like Benjamin (1992), Dillon and Voena (2018), and LaFave and Thomas (2016), we tested this by empirically examining the relationship between labor usage and family demographics. The results in table 3.4 indicates that household size and family labor supply have positive relationships, suggesting the existence of the household non-separability problem. The lack of an empirical relationship between labor hiring and microcredit is not consistent with a recent experiment in Zambia by Fink et al. (2018), who showed that lowering borrowing costs increases demand for labor hiring. The prevalence of labor sharing may explain this difference, as households prefer to supply labor from labor sharing groups rather than hiring.

Compared to non-beneficiaries, farmers purchase more fertilizer after receiving loans from microcredit institutions. The results in table 3.4 report that households purchased 95% more fertilizer (Column 5). Fertilizer usage in Ethiopia is significantly below the average of Sub-Saharan Africa, and agricultural productivity in Ethiopia is still low. For this reason, farmers purchase more fertilizer when illiquidity is relaxed, meaning that microcredit loan usage may

[13] In rural Ethiopia, farmers were familiar with one another, and inefficient farmers would be expelled from the group. This motivates farmers not to maintain efficiency.

increase a household's farm production.

3.5.2 Network loan and fertilizer credit effects

Households supply more labor in labor sharing groups after taking loans from informal networks. Table 3.4 reports that network loan users supplied 22% more labor in labor sharing networks relative to households without network loans (Column 1). It is possible that farmers supply more labor in labor sharing networks after taking network loans because of their increased motivation to participate in the village network. In the village network system, villagers participate in different networks simultaneously and they are interconnected with one other via credit, savings, funeral, and labor networks. For this reason, a person who receives credit from a network is more willing to help neighbors through labor sharing groups. Alternatively, labor sharing participation may increase the individual's likelihood to take loans from the village network at lower transaction costs. If there is a greater possibility to receive credit from the network, then a household is willing to participate in labor sharing networks more actively to receive credit loans. In this case, it appears that there may be a reverse causality between labor sharing and network credit loan-taking.

The positive relationship between labor sharing and network loan might also be due to the prevalence of social norms and peer pressure. For example, loan-taking from networks encourages households to participate more in village network duties, with labor sharing representing one such type of network engagement. In this case, network loan takers involuntarily increase their participation in the labor sharing network. This study's results are consistent to those of Hoddinott et al. (2009), who identified the influence of social pressure on network participation.

Positive relationships between network loans and labor sharing might also be influenced by family reputations. If parents achieve a high reputation by actively participating in village networks, network engagement is easier for their siblings, and children of these parents are more likely to receive loans from network loan services.

Another effect of network credit is that households who have taken network credit loans later purchase more fertilizer. Table 3.4 reports that network loan users purchased 50.6% more fertilizer inputs relative to nonborrowers (Column 5). However, the effect of network loans on fertilizer expenditures is smaller compared to other credit sources. This indicates that the purpose of loan-taking from village networks is not only for agricultural inputs but also for nonagricultural purposes. These results are consistent with Hoddinott et al. (2009), who argued that network credit loans are used more frequently for immediate purposes such as food consumption or payment for health-related expenses.

Fertilizer credit program recipients share less labor with their neighbors. The results in table 3.4 show that fertilizer credit program recipients supplied 19% less labor in labor sharing group compared to nonrecipients. Farmers receive fertilizer as an in-kind loan, so fertilizer credit program recipients use this loan exclusively for fertilizer expenditures. Accordingly, labor supply by sharing networks is substituted by fertilizer usage, and that influences fertilizer credit program beneficiaries to supply fewer working days in labor sharing groups. In particular, all households except the second lowest land size group display negative effects of fertilizer credit programs on labor sharing (table B.9).

Households supply more family labor if they benefit from fertilizer credit programs. Fertilizer credit program recipients purchased 94.6% more fertilizer compared to nonrecipients. A household increases its family labor sufficiently to accompany increased fertilizer usage. The effect of the fertilizer credit program on fertilizer expenditure is similar to the effect of microcredit loans, which suggests that microcredit loan-takers use their borrowed credit to purchase inputs rather than for other purposes.

3.5.3 Other factors influencing farm labor allocation

Household size influences labor sharing. Households with more family members supplied 4.8% less labor in labor sharing network. If a household has a large enough labor force, they are likely less motivated to cooperate with neighbors.

The head of household's age of a household has no effect on labor sharing supply. The head of household's age is in general related to farm experience. If the head of household is old, these households have more networks within the village due to the household's longer greater experience within the village. However, our results show that older farmers with more experience do not have advantages in network arrangements. The results in table 3.4 indicate that age is not necessary for households to form labor sharing group. One possible reason is that labor sharing is reciprocal, and households tend to seek neighbors who have similar abilities or who can manage similar effort levels. For this reason, households with older heads are less desirable to those forming new labor sharing groups, which may countervail any network advantages.

Land size decreases household's labor sharing. Households with 1 more hectare supplied 0.4% less labor days in sharing groups. Land fragmentation does not influence labor supply and input expenditures. In Ethiopia, farmers often acquire their land from the village leader or their family, and the proportion of land purchases remains low. For this reason, land fragmentation in Ethiopia raises labor allocation inefficiency problems. However, land fragmentation unexpectedly has no effects on labor sharing, family labor, or hired labor supply.

Fertilizer usage does not lead households to share more labor, instead leading households to allocate more labor by either family or hired labor. The difference may reflect a degree of independence of individual input decisions and labor sharing arrangements. Since fertilizer usage is an individual decision, change of fertilizer inputs do not impact labor sharing, as this requires mutual agreement. Crop diversity score also has no effect on labor sharing.

3.5.4 Loan size

In this section, we examine if loan amount, rather than the dichotomous uptake of loans, influences household labor choices. The results in table 3.5 report that the amount borrowed from microcredit institutions did not impact labor sharing. Thus, neither evidence from the intensive nor the extensive margin supports an effect on microcredit loan amount. The effects of credit size on other labors, such as labor supplied by family or hired groups, are also statistically insignificant. In fact, a household with greater microcredit loan amounts tend to purchase more fertilizer.

Increases in network loan sizes lead farmers to share labor at a higher rate. Farmers supplied 5% more labor days in labor sharing groups when the network loan amount increased by 1 birr. However, the amount of a network loan has no effect on family or hired labor supply. There also exists a null relationship between network loan amount and fertilizer expenditure.

Fertilizer credit program loan amount has no statistically significant effects on labor sharing. However, fertilizer credit loan amount has positive effects on family labor supply. If the fertilizer credit amount increased by 1 birr, a household supplied 5.6% more family labor. The amount of fertilizer credit also has an impact on fertilizer expenditure. Households purchased 31% more fertilizer if the fertilizer credit amount increased by 1 birr. The effects of loan amount increases on household labor supply and input expenditure are consistent with the dichotomous uptake results. However, the effects of fertilizer credit amount on fertilizer purchase are greater than the effects of microcredit loan amounts, which indicates that households use microcredit loans not only for fertilizer purchases, but also for other purposes as the loan size increases.

3.6 Robustness checks

3.6.1 Village level estimation results

A common concern when estimating impacts of microcredit loans is selection bias. Even when access to loans is exogenously determined, the decision to take a loan may be connected to other time varying household characteristics or shocks. For example, households suffering from a negative shock in between years t and $t+1$ may have both higher demand for credit and worse outcomes in year $t+1$.

There are two distinct groups within non-borrowers: households that applied for a loan but were rejected by the microcredit institution and households that do not want to receive loan services and did not attempt to borrow. An endogeneity problem potentially arises from this individual variation because the unobserved factors that influence individual microcredit loan decisions may also impact labor allocation decisions. However, it is difficult to separate non-borrowers into two groups to avoid the endogeneity problem. An alternative is to do away with the potential household selection problem by estimating at the village level. As a robustness check, we estimate the effects of microcredit loans on labor sharing using village-level averages of dependent and independent variables. The village-level panel regression is:

$$L_j^v = \beta_1^v + \beta_2^v X_v + \beta_3^v D_v + \delta^v + \epsilon_j^v \tag{3.2}$$

where L_j^v is the village-level average of family, shared, and hired labor, with j indicating each labor group. X_v represents village-level covariates; D_v indicates the existence of village-level microcredit loans; and δ^v is the village fixed effect. The subscript v indicates the village. If at least one household in a village v received a microcredit loan, then the village level microcredit indicator $D_v = 1$ holds. However, if no households in the village received microcredit loans, then that village is considered as one where no microcredit loan was available. Thus, equation (3.2) estimates the impact of access to loans.

An alternative way to eliminate the individual level variation is to include village-level means of dependent and independent variables. Equation (3.3) includes village-level means of covariates to control the individual selection bias.

$$L_{it,j} = \beta_{1,j} + \beta_{2,j} X_{it,j} + \beta_{3,j} D_{it,j} + \beta_{4,j} \overline{L_{it,j}} + \beta_{5,j} \overline{X_{it,j}} + \sigma_{i,j} + \epsilon_{it,j} \tag{3.3}$$

where $\overline{L_{it,j}}$ and $\overline{X_{it,j}}$ are the village-level averages of labor days and the covariates at time t. The village-level averages of variables are calculated using all observations of each village excluding household's own observed value. In mathematical form, the village-level average labor days and covariates are $\overline{L_{it,j}} = \frac{1}{N-1} \sum_{i \neq k}^{N} L_{it,j}$ and $\overline{X_{it,j}} = \frac{1}{N-1} \sum_{i \neq k}^{N} X_{it,j}$ where k indicates kth household.

With the household-level selection bias of microcredit loans removed, the results in table 3.6 report that microcredit loans still do not impact labor sharing. Both village-level estimation and village mean controlled estimation results indicate that microcredit loan effects are small (0.046 and 0.047) and statistically insignificant at the 10% level. After eliminating household-level heterogeneity of loan-taking, village-level average of microcredit loan-taking still does not influence the household's labor sharing decision. This result indicates that the household's decision on microcredit participation does not influence labor-sharing arrangement among villagers. This confirms our previous argument that microcredit loan-taking does not change labor sharing supply because labor sharing requires mutual agreements within the group.

Village-level loan availability also induces households to purchase more fertilizer. However, the effect of village-level loan availability is smaller compared to the household-level estimation, and village-level estimation can even be considered insignificant. This indicates that the household's fertilizer expenditure decision depends more on household's loan-taking rather than village loan availability.

3.6.2 Matched Difference-in-Differences (DID)

One potential problem in the analysis thus far is that microcredit take-up of households is not randomly decided. For this reason, the effects of microcredit loan on labor days might not be properly estimated, and the probability of take-up in the microcredit loan market between participants and non-participants is not identified. We employ an alternative method to estimate average treatment effects, Propensity Score Matching (PSM)-DID, (Heckman et al., 1997; Imai et al., 2018; Mazumder and Lu, 2015) as a robustness check at the base of 1999 round. The matched DID method utilizes data from the first survey wave (1999), when take-up was extremely low, to predict households' propensity of receiving microcredit loans in subsequent rounds. The PSM is used to balance treatment and comparison groups using the baseline (i.e. 1999) characteristics to predict subsequent treatment adoption. Using both second (2004) and third (2009) wave, DID becomes a propensity score-weighted regression which estimates the average treatment effects between matched groups.

The matched DID in the reduced form is:

$$L_{it,j} = \beta_{1,j} + \beta_{2,j} X_{it,j} + \beta_{3,j} D_{it,j} + \beta_{4,j} t_j + \beta_{5,j} D_{it,j} \times t_j + e_{it,j} \quad (3.4)$$

where t_j is the survey round in which the household became a loan beneficiary. The cross-equation of treatment $D_{it,j}$ and t captures the differences of the average effects between the treatment and control groups. The coefficient $\beta_{5,j}$ indicates the Average Treatment Effect (ATE) between the t and $t+1$ round. We match the propensity score of microcredit loan recipients and nonrecipients based at year 1999 using the covariates such as household and farm characteristics that used in the analysis. The logistic model was used to predict the propensity score. Then, we computed the ATE by taking the average of the differences between matched recipients and nonrecipients.

The results in table 3.7 report that the average treatment effects between microcredit borrowers and non-borrowers on labor sharing is statistically insignificant, which is consistent with the previous base model. The consistency of the results between base model and matched DID model indicates that nonrandomized survey might not bring potential bias problems in terms of shared-labor days. However, results are inconsistent with the base model, in terms of family labor supply. Using matched DID, we found that microcredit loan-takers supplied more family labor and purchase more fertilizer inputs relative to non-borrowers.

3.6.3 Heterogeneity of microcredit loan effects

Next, we look at the unmatched DID results after selecting two panel years only to investigate potential heterogeneity of the ATE calculated in section 3.5 over different years of microcredit loan taking. Thus, we first estimate the impact of microcredit on labor sharing using equation 3.4 for the years 1999 and 2009, and then redo the analysis using the years 2004 and 2009. The purpose of these analyses is to investigate if the heterogeneity of microcredit loan impacts on labor sharing exists across the survey rounds. The DID results between 1999 and 2009 after excluding 2004 round in table 3.7 indicate that households were 70% more likely to supply labor in labor sharing groups if they received microcredit loan in 2009 (second panel in table 3.7). The results for the 2004 and 2009 rounds after excluding 1999 round in the third panel of table 3.7 also report that the effects of microcredit loan on labor sharing days are positive (0.148), but they are imprecisely estimated. Even if the matched DID result (first panel in table 3.7) is consistent with the base model, the average treatment effects appear heterogeneous when we explicitly allow the identifying variation to occur in different years (1999/2009 and 2004/2009).

One potential explanation is that microcredit loans in 2004 were more transformative with respect to labor sharing networks for the marginal loan adopters than in 2009. Since microcredit institutions in Ethiopia were first introduced in 1996, the proportion of recipients was still low in 1999, and access to microcredit loans remained limited compared to later years. However, the number of loan recipients since 1999 increased rapidly, and tripled by 2004. Furthermore, four major microcredit institutions (Amhara credit and savings institution in Amhara region, Dedebit credit and savings institution in Tigray region, Oromia credit and savings institution in Oromia region and Omo credit and savings institution in SNNP region) in both 2004 and 2009 were prevalent across major regions in Ethiopia (Zwedu, 2014). Even if both the number of microcredit takers and the average outstanding loan size increased between 2004 and 2009, changes in the intensive margin were small (Zwedu, 2014). As a result, it is possible that the marginal microcredit loans in 2004, when microcredit was still relatively new, influenced labor allocation decisions, but subsequent loans did not. That may be the case if earlier loans were made to individuals in less stable sharing networks prone to disruption from injections of liquidity. Due either to demand or heterogeneity in access, later loan adopters may have been more likely to be part of sharing groups invariant to small liquidity changes among members, and thus the 2004 to 2009 treatment effect is smaller. [14]

The main DID estimates pool the impacts across rounds and reduces the visibility of potential heterogeneity. However, the results in table 3.7 suggest that the null effects of microcredit loan on labor in the base model may be driven by 2004/2009 sub-group.

[14] While not dispositive, one piece of evidence against such an explanation, however, is found in table 3.3, which indicates that the majority of those who first adopted microcredit in 2004 did not do so again in 2009.

The positive impacts of microcredit on labor sharing estimated based on the 1999/2004 suggest the possibility of significant individual-level heterogeneity in microcredit impacts. Some previous studies, including De Chaisemartin and D'Haultfoeuille (2018); Goodman-Bacon (2018) and Imai et al. (2018), suggested alternative methods to justify the heterogeneity problem in the DID analysis (Callaway and Sant'Anna, 2019). Following De Chaisemartin and D'Haultfoeuille (2018), we concentrate on the heterogeneity of the microcredit effects and attempt to capture it using Fuzzy Difference-in-Differences (DID) estimation from De Chaisemartin and D'Haultfoeuille (2018). The justification for using Fuzzy DID is that even for effective interventions, the effect may still be zero for some groups. Accordingly, De Chaisemartin and D'Haultfoeuille (2018) used the treatment switchers to examine the effect of the intervention on the non-switching groups within the treatment group.[15]

The study uses the Fuzzy DID method to examine if the heterogeneity in the local average treatment effects (LATE) of treatment groups drives the null ATE results. The treatment group in this study was defined as households that received microcredit loans for the first time either in 2004 or 2009. Other microcredit beneficiaries that received microcredit loan for the first time in 1999 were treated as a control group. We only include households that received microcredit loan in any time in the LATE analysis. Then we separate treatment sub-unit and control sub-unit within microcredit recipients. Control sub-units are groups of microcredit adopters whose exposure to the loan adoption does not change the outcomes of interest. Accordingly, Wald-DID results are LATE results among microcredit recipients with controlling heterogeneity of microcredit effects on household labor supply. The labor days of control groups before and after they received microcredit loan are expressed as $L_{0,post}$ and $L_{0,pre}$, respectively. Thus, the Wald DID estimator W_{DID} is:

$$W_{DID} = \frac{E(L_{1,post}) - E(L_{1,pre}) - [E(L_{0,post}) - E(L_{0,pre})]}{E(D_{1,post}) - E(D_{1,pre}) - [E(D_{0,post}) - E(D_{0,pre})]} \tag{3.5}$$

where $L_{1,post}$ and $L_{1,pre}$ are labor days of the "treatment group" before and after receiving

[15]The switching group, or so-called "treatment group switchers" in this context, is the sub-unit of microcredit recipients that do not change their labor supply or input expenditure and behave like a control group.

microcredit loans. The denominator indicates average changes of treatment group switchers between periods. W_{DID} is a weighted two-stage Least Squares (2SLS) regression where the microcredit dummy D is an excluded instrument and the switching treatment group is an included instrument.

We also calculate an alternative estimand that does not rely on assumptions needed in Wald-DID. Wald-DID requires two assumptions to be satisfied. First, treatment effects do not vary over different years. It means that, there is no heterogeneity of loan effects on subgroups with different adoption years. Second, ATEs are equal if the microcredit effects on labor sharing supply change are the same between recipients and non-recipients. The Wald Time-Corrected (TC) estimator rather assumes there is common trends of the microcredit effects on outcomes within the subgroups. It means that, impact of loans on outcomes are the same only within subgroups that are classified by the microcredit adoption for the first time.[16] Thus, Wald-TC does adjust the heterogeneity of loan effects across the sub-units of loan takers who adopted first in different years. Since both Wald-DID and Wald-TC assume asymptotic normality conditions, we replicated the estimation 1,000 times using bootstrapping.

LATE results using Wald-DID and Wald-TC show that the effects of microcredit loan on labor sharing days and input expenditure are not different from our base model results. Table B.10 reports that the LATE results of microcredit loan on labor sharing days are statistically insignificant. Wald-DID and Wald-TC results of microcredit effects (-0.089 and -0.101) on labor sharing days are smaller in magnitude compared to the LATE results (-0.146) in table B.10.

The LATE results of fertilizer expenditure are also consistent with the Wald-DID and

[16]Microcredit adoption consists of four different types of groups in the ERHS survey from 1999 to 2009. The first group was an early-adopting village that already had households that received microcredit either from NGOs or microcredit institutions (8 such villages were located in Oromia, SNNPR, and Tigray). The second group was a village that first adopted microcredit in 2004. The third group consisted of villages that adopted microcredit first in 2009. The final group was the villages where households never received microcredit (e.g., Somodo in the SNNP region and Bokafia in Oromia). We assume that the microcredit impacts on household's labor supply and input expenditure may be different between the second and the third group. Then the treatment group becomes households that changed their labor supply and input expenditure after they received loans while the control group did not.

Wald-TC results. Positive effects of microcredit loan indicate that loan takers alter their fertilizer purchase even if we exclude households that did not change their input supply. Furthermore, We conclude that the microcredit loan recipients consistently maintain their labor sharing relationship and purchase more inputs.

3.7 Conclusion

Microcredit service in Ethiopia has expanded nationwide since 1996, and this study examines the effects of microcredit loans on household farm labor and input allocation decisions. We found that microcredit recipients do not change their labor sharing and family labor supply but rather purchase more fertilizer inputs relative to non-beneficiaries. Loan-takers do not change their labor sharing supply, which suggests that illiquidity is not the primary driver of labor sharing arrangements. Rather, households are reluctant to change labor supply structures due to the existence of labor sharing network effects. These findings are consistent with Gilligan (2004) and Mekonnen and Dorfman (2017), who emphasized network synergies resulting from labor sharing.

The effects of loan services on labor sharing are heterogeneous across different credit services. Network loan-takers supply more labor days on the labor sharing network. One possible reason for the positive relationship between network loan and labor sharing might be the motivation of receiving loans from village networks through participation in labor sharing groups. However, another implication of these results is that households participate in village networks because of social ties and peer pressure. Fertilizer credit program recipients are less likely to supply their labor in labor sharing network. In particular, owners of small plots of land are less likely to share labor with their neighbors after receiving fertilizer credit services compared to large land holders. This reduced labor sharing might occur because the fertilizer credit program enables the owners to substitute shared labor inputs with fertilizer input expenditure. If this is the case, households without fertilizer credit benefits suffer from lack of inputs, which motivates them to share labor.

Microcredit loans may impact households that suffer from forced network participation.

If households participate in the labor sharing network because of social pressure, then microcredit loans allow them not to oversupply labor as a result of peer pressure. In this case, one of the roles of microcredit might be to target these villagers to increase the inter-household labor allocation efficiency.

Effects of microcredit loans in developing countries are still debated, and there is contention as to whether the credit service really improves households' income levels and livelihoods. In particular, previous research using a randomized trial of microcredit services in Ethiopia has shown that microfinance has limited effects on the agricultural labor structural change (Tarozzi et al., 2015). One potential reason for the lack of changes to labor hiring in Ethiopia is the existence of labor sharing. This study fills a gap in the literature by examining why microcredit effects on labor hiring in Ethiopia differ from those in Zambia (Fink et al., 2018) and Malawi (Ricker-Gilbert, 2014).

Overall, we found that microcredit loans do not have impacts on households' labor supply decisions. Furthermore, farmers' responses in terms of labor supply to network loans and fertilizer credit programs are heterogeneous. All three credit services influence a household to purchase more fertilizer, and this result is consistent with previous studies.

This study has two main limitations. First, this study did not control the group peer effects because of the lack of data. It is possible that labor sharing decisions may be the result of group characteristics influencing labor sharing supply. It may be necessary for future studies on labor sharing to control peer effects of labor sharing groups using information regarding the group members.

Second, this study did not fully control the selection problem such as individual heterogeneity of microcredit loan take-up and access. Households' characteristics, such as income level, wealth, and health changes across years, may influence the microcredit loan-taking decision. Furthermore, loan access in this study was not randomized, but rather microcredit instutions and NGOs selected specific locations. Even though we used fixed effect estimations, there is still some possibility of selection bias as a result of household characteristics and location restrictions. Further studies on the effects of credit services on labor sharing might need to use Randomized-Controlled trials to avoid these selection-bias problems coming from both loan access and take-up.

Figures and tables

Table 3.1: *Average microcredit market participation rates*

		(1)		(2)		(3)	
		1999 round		2004 round		2009 round	
Region	PA (Kebele)	%	SD	%	SD	%	SD
Amhara	Dinki	0.00	0.00	0.00	0.00	4.35	20.54
	Yetmen	0.00	0.00	6.52	24.96	8.89	28.78
	Shumsheha	0.00	0.00	2.11	14.43	10.78	31.17
	D.B, Milki	0.00	0.00	3.92	19.60	9.62	29.77
	D.B, Kormargefia	0.00	0.00	0.00	0.00	19.15	39.77
	D.B, Karafino	0.00	0.00	0.00	0.00	11.11	32.03
	D.B, Bokafia	0.00	0.00	0.00	0.00	0.00	0.00
Oromia	Sirba na Goditi	0.00	0.00	N/A	N/A	14.49	35.46
	Adele Keke	0.00	0.00	0.00	0.00	7.06	25.77
	Korodegaga	1.92	13.80	14.89	35.79	9.09	28.89
	Trirufe/Ketchema	2.22	14.82	0.00	0.00	5.68	23.28
	Bako Tibe	5.48	22.92	N/A	N/A	23.29	42.56
	Somodo	0.00	0.00	N/A	N/A	0.00	0.00
SNNPR	Imdibir	1.54	12.40	0.00	0.00	11.67	32.37
	Aze Deboa	8.33	27.83	0.00	0.00	9.86	30.02
	Adado	0.00	0.00	2.63	16.22	15.00	36.16
	Gara Godo	1.37	11.70	2.74	16.44	5.48	22.92
	Doma	0.00	0.00	0.00	0.00	9.09	29.01
Tigray	Haresaw	25.32	43.76	25.33	43.78	17.95	38.62
	Geblen	11.67	32.37	3.23	17.96	15.00	36.01
	Total	3.24	17.70	4.37	20.45	10.43	30.57
	N	1,329		1,007		1,285	

Source: Ethiopia Rural Household Survey

Table 3.2: *Summary statistics*

	Mean	Std.Dev.	Obs
Household characteristics			
Head is female	0.26	0.44	3,621
Head's age	50.53	14.91	3,621
Head's education years	1.31	2.67	3,621
Household size	5.69	2.95	3,621
Head is farmer	0.75	0.43	3,621
Land size (ha)	1.84	8.73	3,621
Livestock (TLU)	3.82	4.34	3,621
Fragmentation index	0.35	0.21	3,467
Consumption expenditure (birr)	1,909.76	2,397.92	3,329
Real per capital consumption (birr)	78.90	71.44	3,329
Crop diversity score (Simpson index)	0.54	0.23	3,514
Fertilizer expenditure(birr)	417.14	1,126.47	3,621
Credit			
Loan dummy from microcredit	0.06	0.24	3,621
Loan dummy from credit network	0.14	0.34	3,621
Fertilizer credit recipient dummy	0.14	0.35	3,621
Microcredit dummy for agricultural purposes	0.11	0.31	3,621
Fertilizer credit amount (birr)	38.53	218.282	3,621
Loan amount from microcredit (birr)	109.88	530.91	3,621
Loan amount from network (birr)	101.25	446.29	3,621
Distance to the nearest bank (km)	29.49	38.41	3,199

Source: Ethiopia Rural Household Survey

Table 3.3: *Loan transition across sectors in periods 1999, 2004, and 2009*

Transition in terms of loan (1999/2004/2009)	Money lender	Friend/relatives	Bank	Network	Microcredit	Other type of loan
	Fraction of samples (%) (N = 1,124)					
Yes/Yes/Yes	0.09	6.49	0.00	1.25	0.27	0.00
Yes/Yes/No	1.16	5.69	0.00	1.33	0.80	0.00
Yes/No/Yes	0.98	7.92	0.00	2.05	0.53	0.09
Yes/No/No	7.38	11.39	2.05	3.82	2.14	1.42
No/Yes/Yes	0.36	6.41	0.00	6.32	1.25	1.69
No/Yes/No	3.29	8.72	0.09	6.49	5.07	6.14
No/No/Yes	4.18	13.35	0.18	12.19	6.94	8.81
No/No/No	82.56	40.04	97.69	66.55	83.01	81.85

Loan transition from either 1st/2nd round to 3rd round

Transition in terms of loan (1999 or 2004/2009)	Money lender	Friend/relatives	Bank	Network	Microcredit	Other type of loan
	Fraction of samples (%) (N = 1,387)					
Yes/Yes	1.15	18.53	0.00	8.58	1.80	1.44
Yes/No	11.46	23.58	2.02	10.09	6.71	6.42
No/Yes	3.82	15.36	0.14	13.91	8.00	7.64
No/No	83.56	43.54	97.84	67.41	83.49	84.50

Source: Ethiopia Rural Household Survey
Note: Results in the table only includes households surveyed in all 3 rounds (1999, 2004, and 2009). Sum of each column becomes 100%. "Yes/Yes/Yes" stands for households borrowed a loan from one source for all 3 rounds. For example, 3.2% out of 1,124 households borrowed loan from their friends or relatives for all 3 rounds. 'Others' include government, agricultural bureau, church, traditional and rural credit associations.
Second table indicates the loan transition from either 1999 or 2004 to 2009. If the household was benefited by the microcredit loan either in the first or the second round, then it is treated as one response. This table is useful for the households were not included in all three rounds, but only were surveyed either the 1999 or the 2004 round and then 2009 round.

Table 3.4: *Credit market participation and per hectare input changes*

	Labor sharing days (1)	Family labor days (2)	Hired labor days (3)	Total labor days (4)	Fertilizer expenditure (ETB) (5)
Loan from microcredit	0.021	0.157	-0.031	0.044	0.932
	(0.099)	(0.144)	(0.091)	(0.141)	(0.199)***
Loan from credit network	0.223	0.307	-0.052	0.298	0.506
	(0.092)**	(0.111)***	(0.074)	(0.100)***	(0.172)***
Fertilizer credit recipient	-0.190	0.148	0.052	0.099	0.946
	(0.068)***	(0.080)*	(0.063)	(0.074)	(0.163)***
Head is female	-0.005	-0.088	-0.051	-0.081	-0.014
	(0.130)	(0.152)	(0.084)	(0.139)	(0.227)
Head's age	-0.000	-0.013	0.004	-0.012	0.004
	(0.003)	(0.004)***	(0.003)	(0.004)***	(0.007)
Head's education years	0.032	0.027	0.004	-0.002	0.026
	(0.027)	(0.029)	(0.020)	(0.027)	(0.041)
Household size	-0.048	0.040	0.001	0.021	0.004
	(0.014)***	(0.016)**	(0.012)	(0.015)	(0.030)
Head is farmer	0.212	-0.043	0.050	0.093	0.159
	(0.095)**	(0.135)	(0.074)	(0.121)	(0.171)
Land size (ha)	-0.004	-0.018	-0.000	-0.019	-0.007
	(0.002)**	(0.005)***	(0.000)	(0.005)***	(0.003)**
Livestock (TLU)	0.006	0.042	-0.008	0.033	0.092
	(0.009)	(0.011)***	(0.007)	(0.010)***	(0.019)***
Fragmentation index	0.047	0.242	0.053	0.124	-0.290
	(0.158)	(0.220)	(0.121)	(0.206)	(0.288)
Consumption per capita	0.120	0.211	0.043	0.229	0.113
	(0.043)***	(0.057)***	(0.032)	(0.054)***	(0.080)
Crop diversity score	0.191	0.966	0.320	0.901	0.071
	(0.145)	(0.223)***	(0.110)***	(0.212)***	(0.273)
Fertilizer (birr/ha)	0.010	0.105	0.036	0.099	
	(0.012)	(0.014)***	(0.010)***	(0.013)***	
Constant	0.379	3.110	-0.157	3.326	0.667
	(0.394)	(0.462)***	(0.291)	(0.425)***	(0.707)
R^2	0.51	0.43	0.55	0.44	0.69
N	3,114	3,114	3,114	3,114	3,114

Note: *** p< 0.01 ** p< 0.05 * p<0.10.
All labor days and variables that contain monetary values are transformed to Inverse Hyperbolic Sine. This is panel regression with household and round fixed effect and errors are clustered at the household level.

Table 3.5: *Credit amount and per hectare input changes*

	Labor sharing days (1)	Family labor days (2)	Hired labor days (3)	Total labor days (4)	Fertilizer expenditure (ETB) (5)
Microcredit amount (birr)	0.002	0.017	-0.004	0.003	0.100
	(0.013)	(0.019)	(0.012)	(0.018)	(0.025)***
Network loan (birr)	0.046	0.019	0.004	0.024	-0.049
	(0.017)***	(0.021)	(0.013)	(0.019)	(0.029)
Fertilizer credit (birr)	-0.017	0.048	0.009	0.039	0.311
	(0.011)	(0.012)***	(0.011)	(0.011)***	(0.021)***
Head is female	0.003	-0.087	-0.049	-0.079	-0.036
	(0.130)	(0.153)	(0.084)	(0.140)	(0.217)
Head's age	-0.000	-0.013	0.004	-0.012	0.002
	(0.003)	(0.004)***	(0.003)	(0.004)***	(0.006)
Head's education years	0.030	0.027	0.003	-0.002	0.024
	(0.027)	(0.029)	(0.021)	(0.027)	(0.039)
Household size	-0.049	0.040	0.001	0.021	0.009
	(0.014)***	(0.016)**	(0.012)	(0.015)	(0.028)
Head is farmer	0.216	-0.039	0.050	0.097	0.133
	(0.095)**	(0.135)	(0.074)	(0.121)	(0.164)
Land size (ha)	-0.005	-0.018	-0.000	-0.019	-0.006
	(0.002)**	(0.005)***	(0.000)	(0.005)***	(0.003)*
Livestock (TLU)	0.006	0.041	-0.008	0.032	0.083
	(0.009)	(0.011)***	(0.007)	(0.010)***	(0.019)***
Fragmentation index	0.047	0.217	0.058	0.101	-0.313
	(0.158)	(0.220)	(0.121)	(0.205)	(0.279)
Consumption per capita	0.117	0.211	0.041	0.229	0.075
	(0.042)***	(0.058)***	(0.032)	(0.054)***	(0.078)
Crop diversity score	0.175	0.963	0.325	0.896	0.128
	(0.145)	(0.223)***	(0.110)***	(0.213)***	(0.262)
Fertilizer (birr/ha)	0.014	0.099	0.034	0.094	
	(0.013)	(0.014)***	(0.010)***	(0.013)***	
Constant	0.366	3.148	-0.151	3.357	1.040
	(0.394)	(0.463)***	(0.291)	(0.426)***	(0.684)
R^2	0.51	0.43	0.55	0.44	0.71
N	3,114	3,114	3,114	3,114	3,114

Note: *** p< 0.01 ** p< 0.05 * p<0.10.
All labor days and variables that contain monetary values are transformed to Inverse Hyperbolic Sine. Consumer price index (2010 = 100) is applied in fertilizer expenditure, loan amount, and consumption. This is panel regression with household and round fixed effect and errors are clustered at the household level.

Table 3.6: *Estimation results after controlling individual selection bias*

	Labor sharing days (1)	Family labor days (2)	Hired labor days (3)	Total labor days (4)	Fertilizer expenditure (ETB) (5)
Village level estimation					
Microcredit loan	0.046	0.829	0.094	0.745	0.176
	(0.281)	(0.427)*	(0.141)	(0.357)**	(0.438)
Network loan	2.185	6.638	-0.428	5.937	2.673
	(1.468)	(2.231)***	(0.738)	(1.865)***	(2.245)
Fertilizer credit	-1.165	-3.551	0.462	-3.502	2.055
	(0.986)	(1.498)**	(0.495)	(1.252)***	(1.498)
R^2	0.34	0.66	0.33	0.69	0.74
N	53	53	53	53	53
Village mean control					
Loan from microcredit	0.047	0.001	0.001	-0.055	0.680
	(0.115)	(0.130)	(0.107)	(0.130)	(0.195)***
Loan from microcredit	0.059	0.085	-0.020	-0.021	0.747
	(0.099)	(0.135)	(0.092)	(0.132)	(0.190)***
Loan from credit network	0.167	0.286	-0.013	0.215	0.217
	(0.093)*	(0.109)***	(0.074)	(0.100)**	(0.168)
R^2	0.53	0.50	0.55	0.51	0.71
N	3,114	3,114	3,114	3,114	3,114

Note: *** p< 0.01 ** p< 0.05 * p<0.10.
All labor days and variables that contain monetary values are transformed to Inverse Hyperbolic Sine. Consumer price index (2010 = 100) is applied in fertilizer expenditure, loan amount, and consumption. This is panel regression with household and round fixed effect and errors are clustered at the household level.

Table 3.7: *ATE results of microcredit on labor days*

	Labor sharing days (1)	Family labor days (2)	Hired labor days (3)	Total labor days (4)	Fertilizer expenditure (ETB) (5)
Matched-DID results					
Average Treatment Effect	0.037	0.308	-0.112	0.227	1.018
	(0.197)	(0.130)*	(0.222)	(0.147)	(0.278)***
Unmatched DID results for 1999 & 2009					
Microcredit recipient	-0.740	-0.227	-0.085	-0.302	0.740
	(0.084)***	(0.225)	(0.245)	(0.221)	(0.537)
2009 round	-0.060	-0.275	0.113	-0.178	1.544
	(0.085)	(0.088)***	(0.059)*	(0.082)**	(0.164)***
MC loan × 2009	0.700	0.325	0.026	0.265	-0.278
	(0.154)***	(0.270)	(0.272)	(0.264)	(0.605)
Unmatched DID results for 2004 & 2009					
Microcredit recipient	-0.213	0.122	0.097	0.116	0.477
	(0.209)	(0.300)	(0.212)	(0.297)	(0.546)
2009 round	0.198	0.406	0.124	0.498	0.339
	(0.061)***	(0.082)***	(0.054)**	(0.077)***	(0.132)**
MC loan × 2009	0.148	-0.079	-0.138	-0.209	-0.304
	(0.245)	(0.329)	(0.241)	(0.325)	(0.604)
N	2,906	2,906	2,906	2,906	2,906

Note: *** $p< 0.01$ ** $p< 0.05$ * $p<0.10$.
Matched DID in the first panel in table 3.7 uses 1999 as a base year. The ATE was computed by taking the average of the difference between loan takers and nontakers between 1999 and 2004/2009. The second panel in table 3.7 is the ATE results of the microcredit loan effect are between 1999 and 2009 round except 2004 round. The third panel in table 3.7 indicates the ATE results for households between 2004 and 2009. Note that the matched and unmatched DID estimation include covariates that are used in the household fixed effect regression.

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Appendix A

Appendices for Chapter 1

A.1 Additional table and figures on the distribution of structures and domains of controls

A.1.1 Percentage of the sample plots by structure and domain of controls

Table A.1 presents the shares of the sample plot by various combinations of the structures and domains of controls. For example, the first cell of table 1.3 states that 2.536% of the sample plots in Ethiopia a) are solely owned by male, b) have planting decisions solely made by the male, and c) where the male has the sole output management rights. More than half of the sample plots in both countries are jointly managed in terms of planting and outputs– 64.263% in Ethiopia (sum of 6.896%, 2.913%, and 54.454%) and 56.811% in Malawi (sum of 22.540%, 17.575%, and 16.696%). Interestingly, we observe that even in the plots that are either solely owned by male or by female, males and females tend to make joint decisions related to planting and the outputs from the plots.

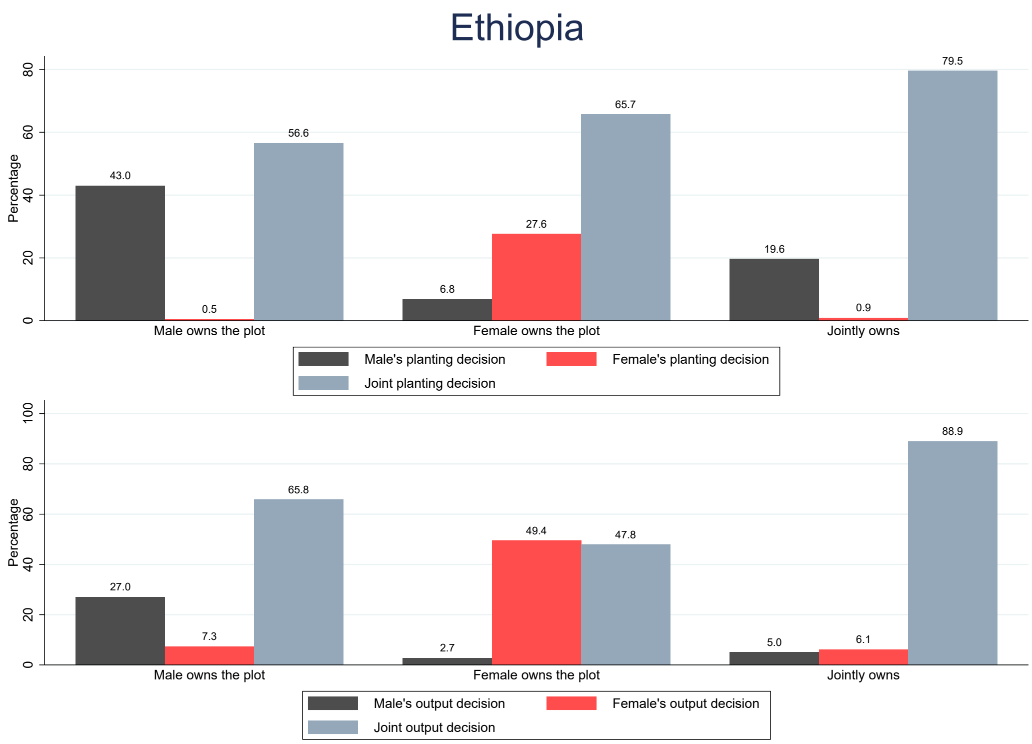
Table A.1: *Percentage of the sample plots by structure and domain of controls*

Ethiopia (n=27,322)		Male has land sales right			Female has land sales right			Joint land sales right		
		Male's output decision	Female's output decision	Joint output decision	Male' output decision	Female's output decision	Joint output decision	Male' output decision	Female's output decision	Joint output decision
Planting decision	Male	2.536	0.49	4.242	0.102	0.113	0.289	1.892	0.772	12.049
	Female	0.004	0.051	0.033	0.007	1.607	0.556	0.011	0.234	0.264
	Joint	2.035	0.651	6.896	0.07	2.24	2.913	1.918	3.569	54.454
Malawi (n=2,276)		Male has land sales right			Female has land sales right			Joint land sales right		
		Male's output decision	Female's output decision	Joint output decision	Male' output decision	Female's output decision	Joint output decision	Male' output decision	Female's output decision	Joint output decision
Planting decision	Male	3.647	0.791	2.812	1.538	0.176	1.274	0.527	0.088	1.098
	Female	0.044	0.615	0.395	0.571	7.953	1.538	0.044	1.318	0.439
	Joint	6.151	1.098	22.54	3.603	3.954	17.575	2.197	1.318	16.696

Sources: World Bank Living Standard Measurement Survey (LSMS) – Integrated Survey on Agriculture (ISA)
Notes: Each cell represents the percentage of the sample plots by structure and domain of controls.
Sum of all 27 cells in each country becomes 100%.

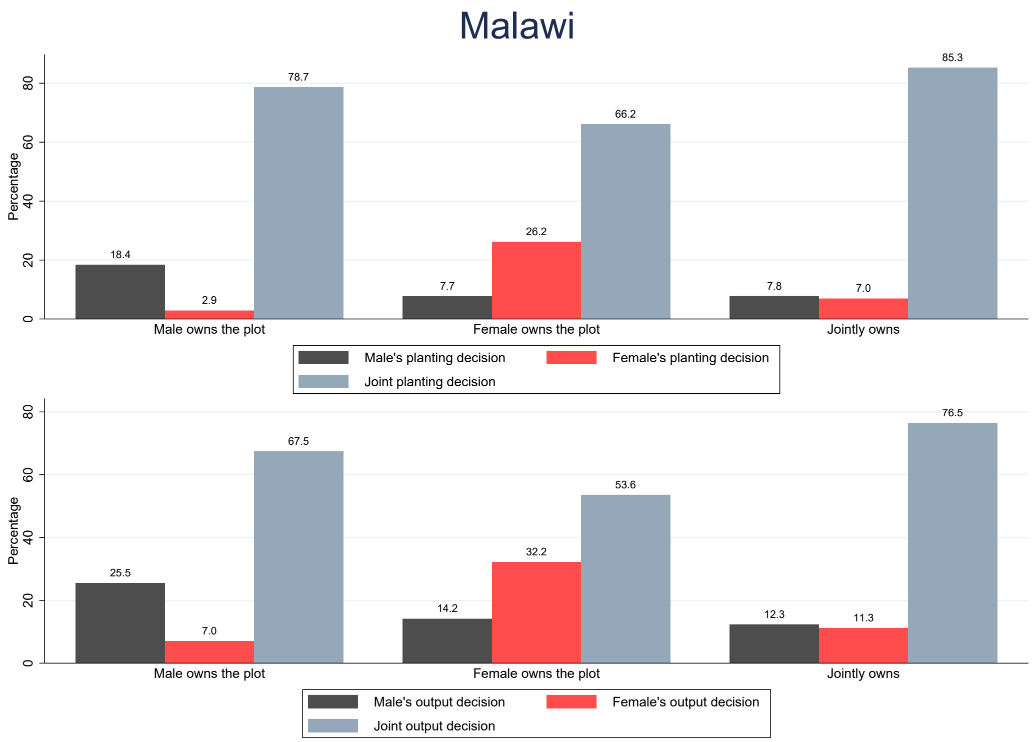
A.1.2 Percentage of plots with gender-specific managerial rights by ownership structure by country

Figure A.1: *Plots with gender-specific managerial rights by ownership structure in Ethiopia*



Source: World Bank Living Standard Measurement Survey (LSMS) – Integrated Survey on Agriculture (ISA)

Figure A.2: *Plots with gender-specific managerial rights by ownership structure in Malawi*



Source: World Bank Living Standard Measurement Survey (LSMS) – Integrated Survey on Agriculture (ISA)

A.2 Alternative estimation methods for estimating equation (1.1)

The estimation in the main analysis relies on a linear probability model to accommodate the household fixed effects specification. As a robustness check, we use the correlated random effect probit model and the conditional logit fixed effects model. The results remain generally robust.

A.2.1 Probit with correlated random effects

Table A.2: *CRE Probit model results of likelihood of ownership leading to managerial rights*

	Female's planting decision (1)	Male's planting decision (2)	Joint planting decision (3)	Female's right on outputs (4)	Male's right on outputs (5)	Joint right on outputs (6)
Female solely has right to sell (α_{1i})	0.054	-0.168	0.057	0.107	-0.057	0.021
	(0.014)***	(0.016)***	(0.025)**	(0.022)***	(0.006)***	(0.020)
Joint right to sell (α_{1i})	-0.003	-0.180	0.204	-0.020	-0.178	0.245
	(0.002)	(0.020)***	(0.021)***	(0.009)**	(0.015)***	(0.019)***
Head is female (Γ_1)	0.205	-0.229	0.031	0.310	-0.063	-0.293
	(0.118)*	(0.026)***	(0.105)	(0.109)***	(0.020)***	(0.096)***
Head's age (Γ_2)	-0.000	-0.001	0.001	-0.001	0.004	-0.003
	(0.000)	(0.003)	(0.003)	(0.001)	(0.002)*	(0.003)
Head's education years (Γ_3)	0.001	-0.010	0.006	0.003	-0.001	-0.002
	(0.001)	(0.008)	(0.009)	(0.002)	(0.004)	(0.007)
Plot size(acre) (Γ_4)	-0.000	0.001	-0.001	-0.011	0.007	0.004
	(0.000)	(0.004)	(0.004)	(0.003)***	(0.003)**	(0.002)**
Plot size sq. (acre) (Γ_5)	0.000	-0.000	0.000	0.000	-0.000	-0.000
	(0.000)	(0.000)	(0.000)	(0.000)***	(0.000)**	(0.000)**
Cultivate cereals only (Γ_6)	-0.002	-0.006	0.010	-0.045	0.005	0.042
	(0.001)***	(0.004)	(0.004)**	(0.004)***	(0.003)	(0.005)***
Organic fertilizer usage (Γ_7)	0.002	-0.017	0.015	0.042	-0.021	-0.020
	(0.002)	(0.007)**	(0.008)*	(0.005)***	(0.004)***	(0.007)***
Fertilizer use (100 kg) (Γ_8)	0.000	0.002	-0.002	-0.005	0.001	-0.000
	(0.000)	(0.001)*	(0.001)**	(0.003)**	(0.001)**	(0.001)
Distance to road(km) (Γ_9)	0.006	-0.112	0.087	0.019	-0.011	-0.007
	(0.006)	(0.065)*	(0.069)	(0.023)	(0.024)	(0.041)
N	29,598	29,598	29,598	29,598	29,598	29,598

Note: *** p< 0.01 ** p<0.05 * p<0.10.
All six equations are estimated with household and round fixed effects. Note that subscript i in coefficient α_{1i} and α_{2i} indicates column number where i=1,. . . 6. Results are marginal effects after CRE Probit regression analysis. Marginal effects are evaluated at the means of the independent variables.
Standard errors are clustered at the household level.

A.2.2 Conditional Logit fixed effects

Table A.3: *Conditional Logit fixed effects model results of likelihood of ownership leading to managerial rights*

	Female's planting decision (1)	Male's planting decision (2)	Joint planting decision (3)	Female's right on outputs (4)	Male's right on outputs (5)	Joint right on outputs (6)
Female solely has right to sell (α_{1i})	0.010	-0.147	0.047	0.053	-0.050	0.030
	(0.003)***	(0.019)***	(0.023)**	(0.015)***	(0.006)***	(0.017)*
Joint right to sell (α_{1i})	-0.019	-0.163	0.197	-0.052	-0.189	0.264
	(0.004)***	(0.018)***	(0.020)***	(0.009)***	(0.015)***	(0.019)***
Head is female (Γ_1)	0.094	-0.177	-0.013	0.309	-0.068	-0.266
	(0.017)***	(0.017)***	(0.026)	(0.035)***	(0.006)***	(0.034)***
Head's age (Γ_2)	-0.001	-0.001	0.001	-0.002	-0.000	0.001
	(0.000)***	(0.000)***	(0.000)***	(0.000)***	(0.000)**	(0.000)**
Head's education years (Γ_3)	0.000	-0.006	0.005	-0.002	-0.002	0.000
	(0.000)	(0.002)***	(0.002)**	(0.001)*	(0.001)*	(0.001)
Plot size(acre) (Γ_4)	0.000	-0.006	0.005	-0.010	0.004	0.005
	(0.000)	(0.005)	(0.004)	(0.006)*	(0.003)	(0.003)
Plot size sq. (acre) (Γ_5)	-0.000	0.000	-0.000	0.000	-0.000	-0.000
	(0.000)	(0.000)	(0.000)	(0.000)*	(0.000)	(0.000)
Cultivate cereals only (Γ_6)	-0.004	-0.030	0.038	-0.059	-0.019	0.083
	(0.001)***	(0.007)***	(0.007)***	(0.005)***	(0.004)***	(0.007)***
Organic fertilizer usage (Γ_7)	-0.001	0.016	-0.020	0.026	-0.013	-0.026
	(0.001)	(0.010)	(0.011)*	(0.005)***	(0.005)**	(0.009)***
Fertilizer use (100 kg) (Γ_8)	0.000	0.002	-0.003	-0.002	0.002	-0.002
	(0.000)	(0.001)	(0.002)*	(0.002)	(0.001)**	(0.002)
Distance to road(km) (Γ_9)	-0.001	0.003	-0.005	-0.010	-0.007	0.010
	(0.000)***	(0.006)	(0.006)	(0.002)***	(0.002)***	(0.004)**

Note: *** $p<0.01$ ** $p<0.05$ * $p<0.10$.
All six equations are estimated with household and round fixed effects. Note that subscript i in coefficient α_{1i} and α_{2i} indicates column number where i=1,...6. Results are marginal effects after fixed effect Logit regression analysis. Marginal effects are evaluated at the means of the independent variables.
Standard errors are clustered at the household level.

A.3 Country-specific estimation of equation (1.1)

As an additional set of robustness check, we conduct country-specific estimation of equation (1.1). While some of the key estimated coefficients from the estimation using only the plots from Malawi differ in magnitude and lose statistical significance, the key results are generally consistent.

Table A.4: *Likelihood of ownership leading to managerial rights in Ethiopia*

	Female's planting decision (1)	Male's planting decision (2)	Joint planting decision (3)	Female's right on outputs (4)	Male's right on outputs (5)	Joint right on outputs (6)
Female solely has right to sell (α_{1i})	0.054	-0.151	0.098	0.103	-0.173	0.070
	(0.028)*	(0.055)***	(0.061)	(0.035)***	(0.033)***	(0.048)
Joint right to sell (α_{1i})	0.000	-0.097	0.097	-0.014	-0.164	0.178
	(0.002)	(0.036)***	(0.036)***	(0.010)	(0.023)***	(0.026)***
Head is female (Γ_1)	0.187	-0.255	0.068	0.298	-0.020	-0.277
	(0.077)**	(0.097)***	(0.133)	(0.092)***	(0.036)	(0.091)***
Head's age (Γ_2)	0.000	-0.000	-0.000	-0.000	0.004	-0.003
	(0.001)	(0.003)	(0.003)	(0.001)	(0.003)	(0.003)
Head's education years (Γ_3)	0.002	-0.012	0.010	0.002	-0.000	-0.002
	(0.002)	(0.010)	(0.011)	(0.003)	(0.006)	(0.008)
Plot size(acre) (Γ_4)	-0.000	-0.000	0.001	-0.005	0.002	0.003
	(0.000)*	(0.004)	(0.004)	(0.001)***	(0.001)*	(0.002)*
Plot size sq. (acre) (Γ_5)	0.000	-0.000	0.000	0.000	-0.000	-0.000
	(0.000)	(0.000)	(0.000)	(0.000)***	(0.000)*	(0.000)*
Cultivate cereals only (Γ_6)	-0.003	-0.005	0.008	-0.045	0.010	0.035
	(0.001)***	(0.004)	(0.004)**	(0.004)***	(0.003)***	(0.004)***
Organic fertilizer usage (Γ_7)	0.004	-0.019	0.015	0.045	-0.022	-0.022
	(0.003)	(0.007)***	(0.008)**	(0.005)***	(0.005)***	(0.007)***
Fertilizer use (100 kg) (Γ_8)	0.000	0.002	-0.003	-0.003	0.003	-0.000
	(0.000)	(0.002)	(0.002)*	(0.001)**	(0.001)**	(0.002)
Distance to road(km) (Γ_9)	0.004	-0.137	0.133	-0.009	0.004	0.005
	(0.012)	(0.085)	(0.086)	(0.032)	(0.030)	(0.044)
N	27,322	27,322	27,322	27,322	27,322	27,322

Note: *** p< 0.01 ** p<0.05 * p<0.10.
All six equations are estimated with household and round fixed effects. Note that subscript i in coefficient α_{1i} and α_{2i} indicates column number where i=1,...6.
Standard errors are clustered at the household level.

Table A.5: *Likelihood of ownership leading to managerial rights in Malawi*

	Female's planting decision (1)	Male's planting decision (2)	Joint planting decision (3)	Female's right on outputs (4)	Male's right on outputs (5)	Joint right on outputs (6)
Female solely has right to sell (α_{1i})	0.056	-0.052	-0.003	0.054	-0.088	0.035
	(0.037)	(0.042)	(0.047)	(0.029)*	(0.045)**	(0.048)
Joint right to sell (α_{1i})	0.019	-0.094	0.075	0.034	-0.078	0.043
	(0.030)	(0.042)**	(0.046)	(0.024)	(0.046)*	(0.048)
Head is female (Γ_1)	0.458	-0.184	-0.274	0.415	-0.153	-0.262
	(0.104)***	(0.089)**	(0.108)**	(0.106)***	(0.119)	(0.076)***
Head's age (Γ_2)	-0.002	0.000	0.002	-0.004	0.003	0.001
	(0.003)	(0.003)	(0.004)	(0.003)	(0.003)	(0.003)
Head's education years (Γ_3)	0.011	-0.011	0.000	0.011	-0.017	0.006
	(0.007)	(0.006)*	(0.008)	(0.007)	(0.008)**	(0.008)
Plot size(acre) (Γ_4)	0.002	0.006	-0.008	0.006	0.006	-0.011
	(0.006)	(0.007)	(0.007)	(0.006)	(0.008)	(0.007)
Plot size sq. (acre) (Γ_5)	-0.000	0.000	-0.000	-0.000	-0.000	0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Cultivate cereals only (Γ_6)	-0.004	0.004	0.001	-0.018	-0.011	0.029
	(0.011)	(0.010)	(0.014)	(0.012)	(0.015)	(0.018)
Organic fertilizer usage (Γ_7)	-0.001	-0.011	0.013	-0.004	0.002	0.002
	(0.017)	(0.018)	(0.024)	(0.019)	(0.027)	(0.028)
Fertilizer use (100 kg) (Γ_8)	-0.001	0.001	0.001	-0.003	-0.007	0.010
	(0.002)	(0.002)	(0.002)	(0.002)	(0.003)***	(0.003)***
Distance to road(km) (Γ_9)	0.046	-0.055	0.009	0.085	-0.020	-0.065
	(0.051)	(0.041)	(0.049)	(0.062)	(0.045)	(0.061)
N	2,276	2,276	2,276	2,276	2,276	2,276

Note: *** $p< 0.01$ ** $p<0.05$ * $p<0.10$.
All six equations are estimated with household and round fixed effects. Note that subscript i in coefficient α_{1i} and α_{2i} indicates column number where i=1,...6.
Standard errors are clustered at the household level.

A.4 Within-equation hypothesis testing from the estimation results of table 1.4

Table A.6, and A.7 present within-equation hypothesis testing results and their rationales of Ethiopia and Malawi using the estimation results in table 4.

Table A.6: *Within-equation restriction test results for Ethiopia*

	Null Hypothesis	Description of Null Hypothesis	Result	Decision
(1)	$\beta_1^m - \beta_4^m = 0$	Male's labor inputs in female-controlled plots and jointly controlled plots are identical.	-0.015	Fail to reject
	(Ownership)		(0.082)	
	$\beta_2^m - \beta_5^m = 0$		-0.390	Reject
	(Planting)		(0.137)***	
	$\beta_3^m - \beta_6^m = 0$		-0.701	Reject
	(Output)		(0.053)***	
(2)	$\beta_1^f - \beta_4^f = 0$	Female's labor inputs in female-controlled plots and jointly controlled plots are identical.	0.097	Fail to reject
	(Ownership)		(0.102)	
	$\beta_2^f - \beta_5^f = 0$		0.448	Reject
	(Planting)		(0.145)***	
	$\beta_3^f - \beta_6^f = 0$		0.453	Reject
	(Output)		(0.053)***	
(3)	$\beta_1^h - \beta_4^h = 0$	Hired labor inputs in female-controlled plots and jointly controlled plots are identical.	0.395	Fail to reject
	(Ownership)		(0.071)	
	$\beta_2^h - \beta_5^h = 0$		-0.011	Fail to reject
	(Planting)		(0.678)	
	$\beta_3^h - \beta_6^h = 0$		-0.236	Reject
	(Output)		(0.032)***	
(4)	$\beta_1^j - \beta_4^j = 0$	Other household labor inputs in female owned plot and jointly owned plot are identical.	0.172	Reject
	(Ownership)		(0.092)*	
	$\beta_2^j - \beta_5^j = 0$		-0.172	Fail to reject
	(Planting)		(0.164)	
	$\beta_3^j - \beta_6^j = 0$		-0.233	Reject
	(Output)		(0.052)***	

Note: *** p< 0.01 ** p< 0.05 * p<0.10.
The subscript 1 - 6 in each coefficient represents female sole ownership, female sole planting decision, female sole output decision, joint ownership, joint planting decision, and joint output decision.
The superscript in each coefficient represent 'm' for 'male's labor', 'f' for 'female's labor', 'o' for 'other household members' labor', and 'h' for 'hired labor'.

Table A.7: *Within-equation restriction test results for Malawi*

	Null Hypothesis	Description of Null Hypothesis	Result	Decision
(1)	$\beta_1^m - \beta_4^m = 0$	Male's labor inputs in female-controlled plots and jointly controlled plots are identical.	-0.162	Fail to reject
	(Ownership)		(0.133)	
	$\beta_2^m - \beta_5^m = 0$		-0.523	Reject
	(Planting)		(0.237)**	
	$\beta_3^m - \beta_6^m = 0$		-0.172	Fail to reject
	(Output)		(0.195)	
(2)	$\beta_1^f - \beta_4^f = 0$	Female's labor inputs in female-controlled plots and jointly controlled plots are identical.	0.038	Fail to reject
	(Ownership)		(0.115)	
	$\beta_2^f - \beta_5^f = 0$		0.300	Reject
	(Planting)		(0.179)*	
	$\beta_3^f - \beta_6^f = 0$		0.026	Fail to reject
	(Output)		(0.166)	
(3)	$\beta_1^h - \beta_4^h = 0$	Hired labor inputs in female-controlled plots and jointly controlled plots are identical.	0.110	Fail to reject
	(Ownership)		(0.136)	
	$\beta_2^h - \beta_5^h = 0$		0.052	Fail to reject
	(Planting)		(0.128)	
	$\beta_3^h - \beta_6^h = 0$		0.181	Fail to reject
	(Output)		(0.162)	
(4)	$\beta_1^j - \beta_4^j = 0$	Other household labor inputs in female owned plot and jointly owned plot are identical.	0.110	Fail to reject
	(Ownership)		(0.187)	
	$\beta_2^j - \beta_5^j = 0$		0.234	Fail to reject
	(Planting)		(0.288)	
	$\beta_3^j - \beta_6^j = 0$		-0.017	Fail to reject
	(Output)		(0.242)	

Note: *** p< 0.01 ** p< 0.05 * p<0.10.
The subscript 1 - 6 in each coefficient represents female sole ownership, female sole planting decision, female sole output decision, joint ownership, joint planting decision, and joint output decision.
The superscript in each coefficient represent 'm' for 'male's labor', 'f' for 'female's labor', 'o' for 'other household members' labor', and 'h' for 'hired labor'.

Appendix B

Appendices for chapter 3

B.1 Additional results

B.1.1 Endogeneity and IVs

One problem we face when we study microcredit loan effects is the endogeneity problem that results from double-selection bias. Berhane and Gardebroek (2011), Pitt and Khandker (1998), Ravallion (2001), and Karlan and Zinman (2011) explained that there are double selection issues when survey data, especially cross-sectional data, is used. First, microcredit institutions screen borrowers because offering loan services to the impoverished entails risk (Postelnicu and Hermes, 2018) and an increased uncertainty of repayment. Furthermore, it is difficult to compare the effects of microcredit loans if microcredit institutions are only located in some villages. This means that the probability of receiving microcredit loan services depends on the existence of microcredit branches within the household's village.

Second, borrowers self-select on the surveys whether they desire to borrow loans or not, meaning this information cannot be accurately captured by researchers. For this reason, nontakers are either those who have been rejected from the microcredit institution or those who do not want to receive a loan. Accordingly, selection of the microcredit loan is influenced by unobserved factors that result in another endogeneity problem.

One of the estimation strategies is to control the time-invariant unobservables using fixed effect panel regression (Berhane and Gardebroek, 2011; Tedeschi, 2008). However, fixed effect regression still assumes there is strong exogeneity of time-varying unobservables, and the individual's selection bias is potentially only from the time-invariant heterogeneity (Berhane and Gardebroek, 2011). Accordingly, microcredit selection-bias at the household level still exists if the endogeneity problem results from time-varying unobservables. For example, health problems suffered by the head of household, business income changes, and idiosyncratic shocks vary across the years, and researchers cannot observe these factors from the survey.

We provide village-level estimation results in table 3.6, which eliminates household level variation of loan-taking. An alternative solution for the endogeneity problem is to use an instrumental variable (IV).[1]. In this study, we used the village-level loan percentage as one of the alternatives. Village-level average microcredit recipient percentage was calculated after excluding kth household's observed value, $\frac{1}{n-1}\sum_{i\neq k}^{n} D_i$. It excludes self-selection of the household and does not directly influence the household's labor allocation decision in the same period. Furthermore, once we used the household fixed effect estimation, the unobserved time-invariant heterogeneity disappeared (Berhane and Gardebroek, 2011). Using village-level microcredit adoption percentage as an IV eliminates the time-variable household heterogeneity. The two-stage Least Squares (2SLS) estimation is:

$$L_{it,j} = \alpha_{1,j} + \alpha_{2,j} X_{it} + \alpha_{3,j} \hat{D_{it}} + \sigma_{i,j} + \delta_{t,j} + \epsilon_{it,j} \tag{B.1}$$

and

$$D_{it} = Z_{it}'\Pi + V \tag{B.2}$$

where $\hat{D_{it}}$ is a predicted value of household microcredit adoption and Z_{it} is an IV.

[1] Previous studies on the effect of microcredit used data including village-level microcredit percentage (Crépon et al., 2015), village-level availability (Islam and Choe, 2013), whether the applicant had their health insurance card in hand (Akotey and Adjasi, 2016), distance from the microcredit institution (Shoji, 2010), landholding (Pitt and Khandker, 1998), amount of microcredit (Islam, 2015), and cost of the loan (Quayes, 2015) However, it is still difficult to determine a valid instrumental variable of microcredit (Berhane and Gardebroek, 2011) because the purpose of the microcredit loan is to improve the income, production, and livelihood of the impoverished and IVs possess a great possibility to violate the exclusion restriction.

Table B.4 reports the 2SLS results which explain how credit market participation influences household labor demand and supply. Microcredit loans do not impact the labor sharing supply, which is consistent with the fixed effect results. However, the magnitude of the effect on family labor supply and fertilizer expenses becomes greater.

B.1.2 Microcredit for agricultural purposes

Because the purpose of microcredit loan-taking is diversified, households may use their loans for consumption, livestock purchase, non-farm business operations, or to repay other loans. In this section, we examine the effect of microcredit loans if the respondent indicated that the loan was for agricultural purposes including input purchase, on-farm labor hiring, and livestock purchase.

Microcredit loans for agricultural purposes do not have impacts on household labor supply decisions. Accordingly, labor sharing, family labor, and labor hiring do not change responding to the microcredit loan. This indicates that no changes in household labor supply are the result of households taking loans for agricultural purposes.

The regression results in table B.3 report that the effect of microcredit on fertilizer expenditure is significantly lower compared to the results in table 3.4, which uses a microcredit dummy for all purposes. Even if the purpose of the microcredit loan was not only for agricultural purposes, the loan indirectly has positive effects on household input purchases. In the case of agriculture-oriented loans, farmers use their borrowed amount for purposes other than input purchase.

Additionally, network loans for agricultural purposes do not have impacts on labor supply decisions. The results in table B.3 report that network effects on labor sharing, family labor, and labor hiring are statistically insignificant. If a household takes network loans for agricultural purposes, this does not change the household's labor supply. This effect is similar to the effects of the microcredit loan. Furthermore, network loan effects on fertilizer expenditure are higher compared to the results in table 3.4. If a household takes network loans for agricultural purposes, the gap of marginal effects on fertilizer expenditure among all types of credit programs becomes smaller. These results regarding fertilizer expenditure show that the effects of credit services on input purchases are similar if the purpose of loan-taking is agricultural usage.

B.1.3 Gender gaps

The gender gap in financial inclusion has been widely reported (Buvinić and O'Donnell, 2019). Therefore, the policy impact of microcredit expenditure could differ by male and female borrowers. In our study, only one-fourth of households reported a female-borrowers. We used a dummy variable which indicated female borrowing households for both microcredit and network loan.

The labor supply decisions of a household are statistically insignificant if women take loans from the microcredit institution or from the network. However, the magnitude of the loan's effects is greater for all labor groups. For example, households supplied 11.3% less shared labor and 39% more family labor days if a female borrower took microcredit loans. Though the impact of women's borrowing on the optimal labor allocation is not significant, this study is consistent with Pitt and Khandker (1998), who reported that women borrowing has a higher impact on labor supply. However, women borrowing loans empowers women's intrahousehold economic power and increases the decision power of labor and input supply. Evidence shows that female-borrowing households purchased 119% more fertilizer, which was around 24% higher than pooled results.

Network loans also do not impact labor sharing and family labor supply if women are the loan-takers. Furthermore, households had 48% less hired days from outside if women took network loans. Additionally, fertilizer expenditures are not impacted by women borrowing the network loan. The effect of network loan-taking by women on labor hiring and fertilizer expenditure suggests that the purpose of women's loan-taking from village networks is more diversified. Since network loan are not only used for agricultural investments, but also for more diversified purposes, there no positive or negative effects of network loans on agricultural activities.

Microcredit in some countries has increased the household's freedom of choice to use the loan to expand the business, for consumption, or for risk management (Banerjee et al., 2015; Buvinić and O'Donnell, 2019). This study's results regarding microcredit loan effects are not consistent with Buvinić and O'Donnell (2019)'s arguments that loan-taking by women increases women's freedom of choice. Rather, our study suggests that female network loan-taking is more relevant to women's economic decision power.

B.1.4 Does income level matter?

Although microcredit is prevalent in developing countries, low-income households are still excluded from the loan benefits (Morvant-Roux, 2011). As a result, the effect of microcredit loans on labor supply can be heterogeneous according to the household income level. In this section, we use consumption per capita during the 1999 survey round as an indicator of income. We then divide households into 4 groups by their consumption quantiles. One reason for using consumption instead of income is that farmers in developing countries do not have consistent monthly incomes, as their wages depend on seasonality. However, consumption amount is more consistent because households consume food and needs every month.

The results in table B.8 indicate that the effect of microcredit loans on labor supply was greater for the upper 25% income groups relative to other income groups. For example, the upper 25% group was more likely to supply both shared and family labor even if these were imprecisely estimated. Furthermore, microcredit loan impacts on fertilizer expenditure in the highest income quantile were also greater relative to other income groups. The highest income groups purchased 125% more fertilizer once they received microcredit loans. This indicates that the highest income groups tend to invest their loans in agriculture to increase farm productivity.

The lowest 25% income group did not change its labor supply arrangement even if they received microcredit loans. Instead, farmers in this group were more likely to invest in the fertilizer purchase, and the effect on the fertilizer expenditure was greater relative to middle income groups.

Microcredit loan effects are heterogeneous across different income groups. However, microcredit loan effects on farm labor supply decisions and fertilizer expenditure are greater in the higher income groups, which indicates that high income groups in Ethiopia take microcredit loans primarily for agricultural purposes. Other income groups take microcredit loans for more diversified purposes.

Network loan impacts on shared and family labor supply were consistent for all income groups except the upper 25% income group. High income group farmers retained a labor sharing network with 1.7% less labor supply on shared labor, but did not marginally allocate more labor even if they borrowed from the village network. This suggests that wealthier households are less likely to suffer from the effects of social ties and peer pressure. However, these households do still maintain their relationships with other villagers, demonstrating that village networking is important regardless of income level.

The network loan effect on fertilizer expenditure is also heterogeneous across income groups. Network loans had null impacts on fertilizer expenditure in low income groups, while high income groups tended to purchase more fertilizer (64% and 82.7% for the 3rd and 4th quantile income groups, respectively) if they received network loans. Lower income groups suffer more from idiosyncratic shock and diversify their usage of loans not only for input investment, but also for immediate uses such as health, education, and consumption. By contrast, higher income groups invest more in fertilizer expenditure, which can increase farm productivity.

The fertilizer credit program consistently influences households' labor supply share negatively across all income groups. Even through the fertilizer credit program effects are statistically insignificant, except for the lower-middle income group, credit-receiving households tend to be less likely to supply their labor in labor sharing network compared to nonrecipients. The effects of the fertilizer credit program on family labor supply are similar, except in high-middle income groups. Fertilizer credit program recipients supplied 33 - 36% more family labor relative to nonrecipients. The fertilizer credit program effects are higher in lower income groups. Lower income groups purchased fertilizer 96 - 99% more than nonrecipients, meaning that the fertilizer credit program can have a greater impact on lower income groups' productivity.

The inclusion of low-income households in the financial market stimulates them to increase production efficiency by allocating more fertilizer inputs. However, labor networking is still important for lower income groups, and they tend to maintain their relationships with other neighbors. For this reason, Morvant-Roux (2011)'s argument regarding the financial market exclusion of the poor is an important consideration for examining the effect.

B.2 Summary statistics by year

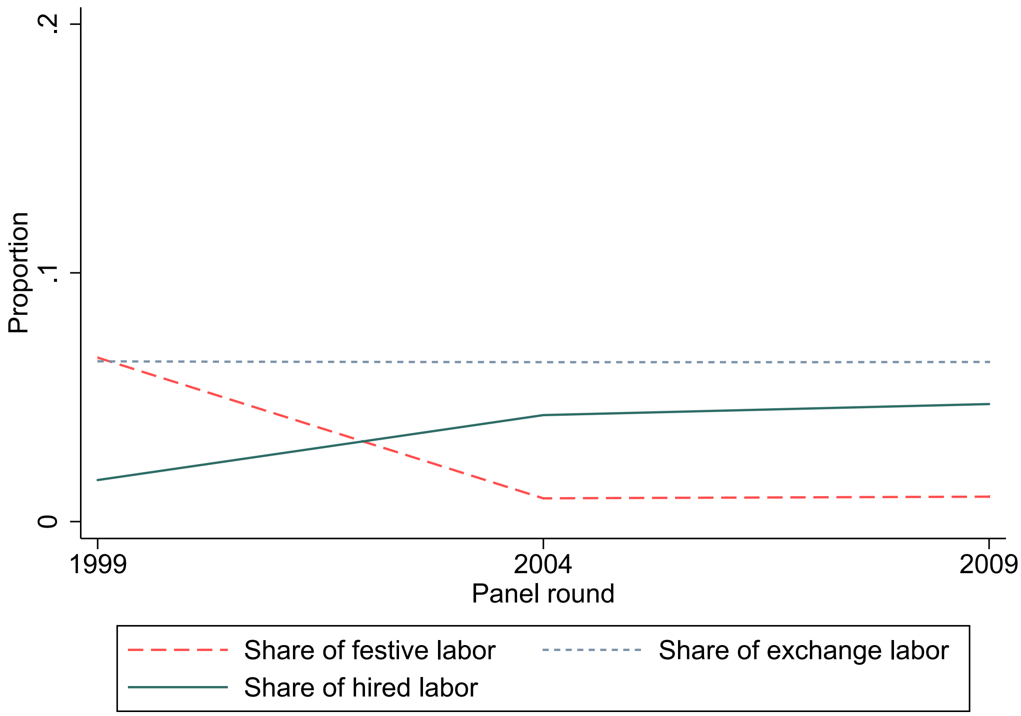
Table B.1: *Summary Statistics of household labor and credit market*

	(1) Pooled sample			(2) 1999 round			(3) 2004 round			(4) 2009 round		
Variables	N	Mean	Std.	N	Mean	Std.	N	Mean	Std.	N	Mean	Std.
Labor sharing participation	3,621	0.52	0.50	1,329	0.59	0.49	1,007	0.49	0.50	1,285	0.48	0.50
Family labor days	3,621	98.06	142.25	1,329	75.69	111.22	1,007	94.80	136.70	1,285	123.74	168.62
Labor sharing days	3,621	8.79	27.38	1,329	16.69	41.50	1,007	3.27	9.51	1,285	4.94	12.53
Hired labor days	3,621	3.66	22.10	1,329	1.62	5.69	1,007	3.66	19.91	1,285	5.78	32.00
Family labor share	3,360	0.87	0.2	1,237	0.85	0.15	920	0.88	0.22	1,203	0.88	0.23
Exchange labor share	3,360	0.09	0.18	1,237	0.13	0.15	920	0.07	0.18	1,203	0.07	0.19
Hired labor share	3,360	0.03	0.12	1,237	0.02	0.04	920	0.04	0.14	1,203	0.05	0.15
Labor sharing group size	3,621	6.53	11.39	1,329	8.68	13.87	1,007	4.2	8.09	1,285	6.12	10.33
Loan dummy	3,621	0.57	0.50	1,329	0.51	0.50	1,007	0.54	0.50	1,285	0.65	0.48
Microcredit loan	3,621	0.06	0.24	1,329	0.03	0.18	1,007	0.04	0.20	1,285	0.10	0.31
Network loan	3,621	0.14	0.34	1,329	0.07	0.26	1,007	0.15	0.35	1,285	0.20	0.40
Microcredit amount (birr)	3,621	109.88	530.91	1,329	45.50	283.58	1,007	61.49	349.82	1,285	214.38	773.66
Network amount (birr)	3,621	50.33	281.02	1,329	39.38	215.46	1,007	56.39	336.70	1,285	56.92	292.60
Fertilizer credit program participate	3,621	0.14	0.35	1,329	0.08	0.28	1,007	0.18	0.38	1,285	0.16	0.37
Fertilizer credit amount (birr)	3,621	101.25	446.29	1,329	18.23	209.57	1,007	112.58	325.08	1,285	178.24	648.18
Loan lender amount (birr)	3,621	25.77	262.81	1,329	45.09	413.25	1,007	12.82	94.88	1,285	15.95	102.10
Loan amount from neighbor (birr)	3,621	143.76	494.51	1,329	114.67	348.97	1,007	156.61	669.58	1,285	163.77	459.16
Amount of loan only for households that received loans												
Microcredit amount (birr)	216	1841.97	1241.17	42	1439.64	740.73	40	1547.89	892.70	134	2055.85	1401.51
Microcredit amount (USD)	216	127.91	86.19	42	99.97	51.44	40	107.49	61.99	134	142.76	97.32
Network amount (birr)	363	502.07	749.85	94	556.72	609.72	117	485.31	879.33	152	481.18	722.83
Network amount (USD)	363	34.86	52.07	94	38.66	42.34	117	33.70	61.06	152	33.41	50.19
Fertilizer credit amount (birr)	406	903.06	1026.83	39	621.33	1072.51	172	659.13	509.25	195	1174.57	1266.66
Fertilizer credit amount (USD)	406	62.71	71.30	39	43.15	74.47	172	45.77	35.36	195	81.56	87.96

Source: Ethiopia Rural Household Survey
Note: Official exchange rate of Ethiopian Birr in 1999, 2004, and 2009 was 7.94, 8.64, and 11.78 birr per USD (Source: World Bank). Consumer price index (2010 = 100) is applied in the credit amounts.

B.3 Labor share changes except family labor

Figure B.1: *Labor share changes by group except family labor*



Source: Ethiopian Rural Household Survey

B.4 Microcredit loan between 2009 and two other years

Table B.2: *Average microcredit market participation rates*

		(1)		(2)	
		1999/2004 round		2009 round	
Region	PA (Kebele)	%	SD	%	SD
Amhara	Dinki	0.00	0.00	4.35	20.54
	Yetmen	3.19	17.67	8.89	28.78
	Shumsheha	0.98	9.88	10.78	31.17
	D.B, Milki	1.87	13.61	9.62	29.77
	D.B, Kormargefia	0.00	0.00	19.15	39.77
	D.B, Karafino	0.00	0.00	11.11	32.03
	D.B, Bokafia	0.00	0.00	0.00	0.00
Oromia	Sirba na Goditi	0.00	0.00	14.49	35.46
	Adele Keke	0.00	0.00	7.06	25.77
	Korodegaga	8.08	27.32	9.09	28.89
	Trirufe/Ketchema	1.16	10.75	5.68	23.28
	Bako Tibe	5.48	22.92	23.29	42.56
	Somodo	0.00	0.00	0.00	0.00
SNNPR	Imdibir	0.78	8.84	11.67	32.37
	Aze Deboa	4.14	19.99	9.86	30.02
	Adado	1.27	11.25	15.00	36.16
	Gara Godo	2.05	14.24	5.48	22.92
	Doma	0.00	0.00	9.09	29.01
Tigray	Haresaw	25.32	43.63	17.95	38.62
	Geblen	8.79	28.47	15.00	36.01
	Total	3.72	18.94	10.43	30.57

Source: Ethiopia Rural Household Survey

B.5 Supplementary regression results

Table B.3: *Microcredit for agricultural purposes and per hectare input changes*

	Labor sharing days (1)	Family labor days (2)	Hired labor days (3)	Total labor days (4)	Fertilizer expenditure (ETB) (5)
Microcredit for ag. purposes	-0.034	-0.036	0.088	-0.079	0.809
	(0.152)	(0.175)	(0.127)	(0.163)	(0.290)***
Network loan for ag. purposes	0.056	0.160	-0.074	0.206	0.784
	(0.114)	(0.108)	(0.081)	(0.096)**	(0.188)***
Fertilizer credit recipient	-0.170	0.186	0.060	0.128	0.885
	(0.072)**	(0.079)**	(0.066)	(0.073)*	(0.169)***
Head is female	-0.001	-0.089	-0.040	-0.080	-0.035
	(0.139)	(0.158)	(0.088)	(0.147)	(0.239)
Head's age	-0.000	-0.010	0.003	-0.010	0.004
	(0.003)	(0.004)**	(0.003)	(0.004)**	(0.007)
Head's education years	0.032	0.029	0.007	0.003	0.033
	(0.027)	(0.030)	(0.021)	(0.028)	(0.040)
Household size	-0.048	0.049	-0.002	0.027	-0.001
	(0.015)***	(0.017)***	(0.013)	(0.015)*	(0.031)
Head is farmer	0.210	0.028	0.063	0.191	0.149
	(0.104)**	(0.140)	(0.078)	(0.126)	(0.186)
Land size (ha)	-0.004	-0.018	-0.000	-0.019	-0.007
	(0.002)**	(0.005)***	(0.000)	(0.005)***	(0.003)**
Livestock (TLU)	0.005	0.027	-0.004	0.021	0.089
	(0.009)	(0.011)**	(0.007)	(0.010)**	(0.019)***
Fragmentation index	0.016	0.331	0.066	0.194	-0.313
	(0.168)	(0.226)	(0.127)	(0.213)	(0.300)
Consumption per capita	0.123	0.155	0.054	0.182	0.096
	(0.045)***	(0.060)***	(0.033)	(0.056)***	(0.083)
Crop diversity score	0.171	1.028	0.298	0.910	-0.047
	(0.157)	(0.233)***	(0.116)**	(0.224)***	(0.289)
Fertilizer (birr/ha)	0.012	0.112	0.034	0.105	
	(0.013)	(0.014)***	(0.010)***	(0.013)***	
Constant	0.434	3.081	-0.187	3.294	0.989
	(0.413)	(0.475)***	(0.301)	(0.438)***	(0.729)
R^2	0.03	0.13	0.03	0.13	0.20
N	2,906	2,906	2,906	2,906	2,906

Note: *** p< 0.01 ** p< 0.05 * p<0.10.
All labor days and variables that contain monetary values are transformed to Inverse Hyperbolic Sine. This is panel regression with household fixed effect and errors are clustered at the household level. Consumer price index (2010 = 100) is applied in fertilizer expenditure, loan amount, and consumption. This is panel regression with household and round fixed effect and errors are clustered at the household level.

Table B.4: *IV results for credit market participation and per hectare input changes*

First stage	Microcredit loan				
Village Microcredit %	0.997				
	(0.126)***				
	Labor sharing days (1)	Family labor days (2)	Hired labor days (3)	Total labor days (4)	Fertilizer expenditure (ETB) (5)
Loan from microcredit	0.351	1.789	-0.501	2.461	6.850
	(0.781)	(0.980)*	(0.577)	(0.945)***	(1.561)***
Loan from credit network	0.256	0.365	-0.067	0.406	0.798
	(0.100)**	(0.126)***	(0.074)	(0.121)***	(0.205)***
Fertilizer credit recipient	-0.199	0.150	0.061	0.090	0.812
	(0.084)**	(0.106)	(0.062)	(0.102)	(0.176)***
Head is female	0.002	-0.085	-0.041	-0.075	-0.034
	(0.122)	(0.153)	(0.090)	(0.147)	(0.254)
Head's age	-0.000	-0.009	0.003	-0.009	0.006
	(0.004)	(0.005)**	(0.003)	(0.004)**	(0.008)
Head's education years	0.032	0.035	0.005	0.012	0.055
	(0.022)	(0.027)	(0.016)	(0.026)	(0.046)
Household size	-0.049	0.044	-0.001	0.021	-0.015
	(0.015)***	(0.019)**	(0.011)	(0.018)	(0.031)
Head is farmer	0.203	0.006	0.068	0.161	0.086
	(0.097)**	(0.122)	(0.072)	(0.118)	(0.204)
Land size (ha)	-0.005	-0.019	0.000	-0.020	-0.009
	(0.003)	(0.004)***	(0.002)	(0.004)***	(0.006)
Livestock (TLU)	0.007	0.031	-0.005	0.027	0.100
	(0.011)	(0.014)**	(0.008)	(0.013)**	(0.023)***
Fragmentation index	0.029	0.302	0.081	0.143	-0.480
	(0.169)	(0.212)	(0.125)	(0.204)	(0.352)
Consumption per capita	0.119	0.152	0.054	0.179	0.097
	(0.046)***	(0.058)***	(0.034)	(0.055)***	(0.096)
Crop diversity score	0.180	1.012	0.307	0.880	-0.115
	(0.162)	(0.203)***	(0.120)**	(0.196)***	(0.338)
Fertilizer (birr/ha)	0.008	0.099	0.038	0.086	
	(0.014)	(0.017)***	(0.010)***	(0.017)***	
First-stage F statistics	62.91	*Prob> F*	0.0000		
Cragg-Donald Weak IV test	62.91				
Endogeneity test	7.915	$\chi^2(1)$ *P-val*	0.0049		
N	2,906	2,906	2,906	2,906	2,906

Note: *** p< 0.01 ** p< 0.05 * p<0.10. All labor days and variables that contain monetary values are transformed to Inverse Hyperbolic Sine. This is panel regression with household and round fixed effect and errors are clustered at the household level. Consumer price index (2010 = 100) is applied in fertilizer expenditure, loan amount, and consumption. This is panel regression with household and round fixed effect and errors are clustered at the household level.

Table B.5: *Credit market participation and total input changes*

Fixed effect results	Labor sharing days (1)	Family labor days (2)	Hired labor days (3)	Total labor days (4)	Fertilizer expenditure (ETB) (5)
Loan from microcredit	0.021	0.076	-0.011	0.030	0.952
	(0.127)	(0.139)	(0.113)	(0.134)	(0.224)***
Loan from credit network	0.147	0.175	-0.021	0.181	0.512
	(0.092)	(0.105)*	(0.079)	(0.094)*	(0.176)***
Fertilizer credit recipient	-0.192	0.216	0.108	0.178	0.916
	(0.078)**	(0.077)***	(0.080)	(0.070)**	(0.170)***
Head is female	0.051	-0.108	-0.005	-0.106	-0.044
	(0.139)	(0.140)	(0.095)	(0.127)	(0.242)
Head's age	0.000	-0.008	0.002	-0.007	0.004
	(0.004)	(0.004)*	(0.003)	(0.004)*	(0.007)
Head's education years	0.036	0.037	0.002	0.019	0.032
	(0.024)	(0.025)	(0.019)	(0.022)	(0.041)
Household size	-0.042	0.068	0.000	0.050	-0.003
	(0.016)***	(0.015)***	(0.014)	(0.013)***	(0.031)
Head is farmer	0.161	0.157	0.126	0.247	0.174
	(0.102)	(0.119)	(0.079)	(0.106)**	(0.187)
Land size (ha)	0.000	-0.000	0.004	-0.001	-0.007
	(0.002)	(0.002)	(0.003)	(0.002)	(0.003)**
Livestock (TLU)	0.021	0.060	0.021	0.055	0.092
	(0.011)*	(0.010)***	(0.009)**	(0.010)***	(0.019)***
Fragmentation index	-0.137	-0.231	0.014	-0.341	-0.333
	(0.169)	(0.204)	(0.129)	(0.191)*	(0.303)
Consumption per capita	0.120	0.113	0.037	0.141	0.098
	(0.046)***	(0.053)**	(0.035)	(0.050)***	(0.083)
Crop diversity score	0.285	1.226	0.324	1.152	0.006
	(0.161)*	(0.201)***	(0.124)***	(0.190)***	(0.290)
Fertilizer (birr/ha)	0.011	0.105	0.034	0.103	
	(0.013)	(0.012)***	(0.011)***	(0.012)***	
Constant	0.342	2.863	-0.165	3.011	0.926
	(0.413)	(0.428)***	(0.320)	(0.390)***	(0.733)
R^2	0.50	0.60	0.59	0.61	0.69
N	2,906	2,906	2,906	2,906	2,906

Note: *** p< 0.01 ** p< 0.05 * p<0.10.
All labor days and variables that contain monetary values are transformed to Inverse Hyperbolic Sine. This is panel regression with household and round fixed effect and errors are clustered at the household level. Instrumental variable for microcredit is the village average microcredit recipient in the proportional form.

Table B.6: *Credit amount and total input changes*

	Labor sharing days (1)	Family labor days (2)	Hired labor days (3)	Total labor days (4)	Fertilizer expenditure (ETB) (5)
Microcredit amount (birr)	0.001	0.013	-0.002	0.007	0.117
	(0.016)	(0.018)	(0.015)	(0.018)	(0.029)***
Network loan (birr)	0.029	-0.004	0.007	0.001	-0.050
	(0.016)*	(0.019)	(0.013)	(0.017)	(0.031)
Fertilizer credit (birr)	-0.015	0.048	0.023	0.044	0.298
	(0.016)	(0.015)***	(0.016)	(0.013)***	(0.027)***
Head is female	0.051	-0.092	-0.001	-0.090	-0.024
	(0.140)	(0.140)	(0.095)	(0.126)	(0.237)
Head's age	0.000	-0.008	0.002	-0.007	0.004
	(0.004)	(0.004)**	(0.003)	(0.004)*	(0.007)
Head's education years	0.035	0.034	0.002	0.015	0.032
	(0.024)	(0.025)	(0.020)	(0.022)	(0.041)
Household size	-0.043	0.068	0.000	0.050	-0.002
	(0.016)***	(0.015)***	(0.014)	(0.013)***	(0.030)
Head is farmer	0.162	0.152	0.128	0.242	0.172
	(0.103)	(0.119)	(0.079)	(0.107)**	(0.185)
Land size (ha)	0.000	-0.000	0.004	-0.001	-0.007
	(0.002)	(0.002)	(0.003)	(0.002)	(0.003)**
Livestock (TLU)	0.021	0.059	0.021	0.055	0.085
	(0.011)*	(0.010)***	(0.009)**	(0.010)***	(0.019)***
Fragmentation index	-0.134	-0.252	0.020	-0.359	-0.353
	(0.169)	(0.204)	(0.130)	(0.191)*	(0.298)
Consumption per capita	0.113	0.121	0.037	0.148	0.105
	(0.045)**	(0.053)**	(0.035)	(0.050)***	(0.082)
Crop diversity score	0.278	1.221	0.328	1.146	-0.017
	(0.161)*	(0.201)***	(0.124)***	(0.191)***	(0.285)
Fertilizer (birr/ha)	0.012	0.103	0.032	0.101	
	(0.013)	(0.012)***	(0.011)***	(0.011)***	
Constant	0.363	2.854	-0.177	3.007	0.989
	(0.413)	(0.428)***	(0.320)	(0.388)***	(0.724)
R^2	0.50	0.60	0.59	0.61	0.70
N	2,906	2,906	2,906	2,906	2,906

Note: *** p< 0.01 ** p< 0.05 * p<0.10.
All labor days and variables that contain monetary values are transformed to Inverse Hyperbolic Sine. This is panel regression with household and round fixed effect and errors are clustered at the household level.

Table B.7: *Labor demand results of female borrowers*

	Labor sharing days (1)	Family labor days (2)	Hired labor days (3)	Total labor days (4)	Fertilizer expenditure (ETB) (5)
Women took a loan from MC	-0.113	0.386	0.183	0.297	1.191
	(0.225)	(0.260)	(0.232)	(0.257)	(0.367)***
Women took a network loan	0.338	-0.113	-0.480	-0.050	0.155
	(0.273)	(0.358)	(0.259)*	(0.312)	(0.443)
Fertilizer credit recipient	-0.175	0.241	0.109	0.203	0.995
	(0.078)**	(0.075)***	(0.079)	(0.067)***	(0.169)***
Head is female	0.048	-0.116	-0.002	-0.113	-0.075
	(0.140)	(0.140)	(0.095)	(0.127)	(0.243)
Head's age	0.000	-0.008	0.002	-0.007	0.004
	(0.004)	(0.004)*	(0.003)	(0.004)*	(0.007)
Head's education years	0.037	0.037	0.001	0.020	0.032
	(0.024)	(0.025)	(0.019)	(0.022)	(0.041)
Household size	-0.043	0.068	0.001	0.050	-0.001
	(0.016)***	(0.015)***	(0.014)	(0.013)***	(0.031)
Head is farmer	0.165	0.155	0.122	0.246	0.179
	(0.103)	(0.119)	(0.079)	(0.106)**	(0.188)
Land size (ha)	0.000	-0.000	0.005	-0.001	-0.007
	(0.002)	(0.002)	(0.003)	(0.002)	(0.003)**
Livestock (TLU)	0.020	0.059	0.022	0.054	0.088
	(0.011)*	(0.010)***	(0.009)**	(0.010)***	(0.019)***
Fragmentation index	-0.141	-0.260	-0.001	-0.368	-0.382
	(0.170)	(0.204)	(0.129)	(0.190)*	(0.302)
Consumption per capita	0.123	0.115	0.036	0.143	0.102
	(0.045)***	(0.053)**	(0.035)	(0.050)***	(0.083)
Crop diversity score	0.282	1.214	0.316	1.139	-0.004
	(0.161)*	(0.201)***	(0.123)**	(0.190)***	(0.290)
Fertilizer (birr/ha)	0.013	0.105	0.033	0.103	
	(0.013)	(0.012)***	(0.011)***	(0.011)***	
Constant	0.331	2.884	-0.150	3.028	0.983
	(0.413)	(0.428)***	(0.320)	(0.390)***	(0.735)
R^2	0.03	0.14	0.05	0.15	0.19
N	2,906	2,906	2,906	2,906	2,906

Note: *** p< 0.01 ** p< 0.05 * p<0.10.
All labor days and variables that contain monetary values are transformed to Inverse Hyperbolic Sine.
This is panel regression with household fixed effect and errors are clustered at the household level.
Consumer price index (2010 = 100) is applied in fertilizer expenditure, loan amount, and consumption.
This is panel regression with household fixed effect and errors are clustered at the household level.

Table B.8: *Consumption quantile and household labor demand*

	Labor sharing days (1)	Family labor days (2)	Hired labor days (3)	Total labor days (4)	Fertilizer expenditure (ETB) (5)
1st quantile (lower 25%)					
Loan from microcredit	0.064	0.031	0.016	-0.037	0.755
	(0.209)	(0.236)	(0.168)	(0.223)	(0.432)*
Loan from credit network	0.295	0.142	0.353	0.211	0.254
	(0.202)	(0.215)	(0.122)***	(0.174)	(0.402)
Fertilizer credit recipient	-0.093	0.329	0.068	0.295	0.962
	(0.179)	(0.158)**	(0.141)	(0.147)**	(0.352)***
N	747	747	747	747	747
2nd quantile					
Loan from microcredit	-0.175	-0.179	0.242	-0.137	0.625
	(0.313)	(0.323)	(0.276)	(0.325)	(0.472)
Loan from credit network	0.238	0.255	-0.139	0.214	0.450
	(0.183)	(0.204)	(0.152)	(0.198)	(0.317)
Fertilizer credit recipient	-0.409	0.335	-0.167	0.147	0.995
	(0.156)***	(0.151)**	(0.172)	(0.145)	(0.333)***
N	741	741	741	741	741
3rd quantile					
Loan from microcredit	-0.013	0.016	-0.297	-0.063	0.677
	(0.175)	(0.280)	(0.210)	(0.273)	(0.428)
Loan from credit network	0.164	0.154	-0.170	0.100	0.639
	(0.181)	(0.198)	(0.176)	(0.188)	(0.313)**
Fertilizer credit recipient	-0.095	-0.192	0.107	-0.106	0.446
	(0.154)	(0.159)	(0.156)	(0.139)	(0.337)
N	724	724	724	724	724
4th quantile (upper 25%)					
Loan from microcredit	0.247	0.383	-0.010	0.349	1.250
	(0.326)	(0.267)	(0.268)	(0.238)	(0.471)***
Loan from credit network	-0.017	0.229	-0.143	0.280	0.827
	(0.192)	(0.235)	(0.186)	(0.199)	(0.362)**
Fertilizer credit recipient	-0.193	0.360	0.318	0.339	0.742
	(0.147)	(0.142)**	(0.162)*	(0.127)***	(0.315)**
N	712	712	712	712	712

Note: *** p< 0.01 ** p< 0.05 * p<0.10.
Consumption per capita quatile has been divided based on the 1999 round household consumption. All labor days and variables that contain monetary values are transformed to Inverse Hyperbolic Sine. This is panel regression with household fixed effect and errors are clustered at the household level. Consumer price index (2010 = 100) is applied in fertilizer expenditure, loan amount, and consumption. This is panel regression with household fixed effect and errors are clustered at the household level.

Table B.9: *Land size quantile and household labor demand*

	Labor sharing days (1)	Family labor days (2)	Hired labor days (3)	Total labor days (4)	Fertilizer expenditure (ETB) (5)
1st quantile (lower 25%)					
Loan from microcredit	0.438	-0.736	0.099	-0.707	-0.461
	(0.321)	(0.382)*	(0.336)	(0.377)*	(0.595)
Loan from credit network	0.179	-0.006	0.006	-0.060	-0.106
	(0.144)	(0.219)	(0.110)	(0.193)	(0.320)
Fertilizer credit recipient	-0.591	0.431	0.368	0.352	0.622
	(0.199)***	(0.207)**	(0.147)**	(0.189)*	(0.352)*
N	549	549	549	549	549
2nd quantile					
Loan from microcredit	-0.048	-0.037	0.144	-0.060	0.769
	(0.254)	(0.288)	(0.155)	(0.270)	(0.450)*
Loan from credit network	0.600	0.272	-0.155	0.351	0.254
	(0.280)**	(0.249)	(0.119)	(0.198)*	(0.388)
Fertilizer credit recipient	0.027	0.213	0.304	0.257	1.687
	(0.240)	(0.254)	(0.154)**	(0.218)	(0.502)***
N	679	679	679	679	679
3rd quantile					
Loan from microcredit	0.071	0.106	-0.233	0.142	0.744
	(0.283)	(0.210)	(0.287)	(0.182)	(0.468)
Loan from credit network	0.132	0.076	0.034	0.081	0.281
	(0.175)	(0.181)	(0.181)	(0.168)	(0.379)
Fertilizer credit recipient	-0.066	0.300	0.030	0.301	0.990
	(0.169)	(0.143)**	(0.176)	(0.131)**	(0.313)***
N	792	792	792	792	792
4th quantile (upper 25%)					
Loan from microcredit	-0.019	0.272	-0.166	0.177	1.261
	(0.218)	(0.189)	(0.216)	(0.175)	(0.380)***
Loan from credit network	-0.179	0.362	0.059	0.324	1.152
	(0.175)	(0.200)*	(0.187)	(0.194)*	(0.326)***
Fertilizer credit recipient	-0.121	0.001	-0.061	-0.030	0.548
	(0.111)	(0.112)	(0.127)	(0.102)	(0.266)**
N	804	804	804	804	804

Note: *** p< 0.01 ** p< 0.05 * p<0.10.
Consumption per capita quatile has been divided based on the 1999 round household consumption.
All labor days and variables that contain monetary values are transformed to Inverse Hyperbolic Sine. This is panel regression with household fixed effect and errors are clustered at the household level. Consumer price index (2010 = 100) is applied in fertilizer expenditure, loan amount, and consumption. This is panel regression with household fixed effect and errors are clustered at the household level.

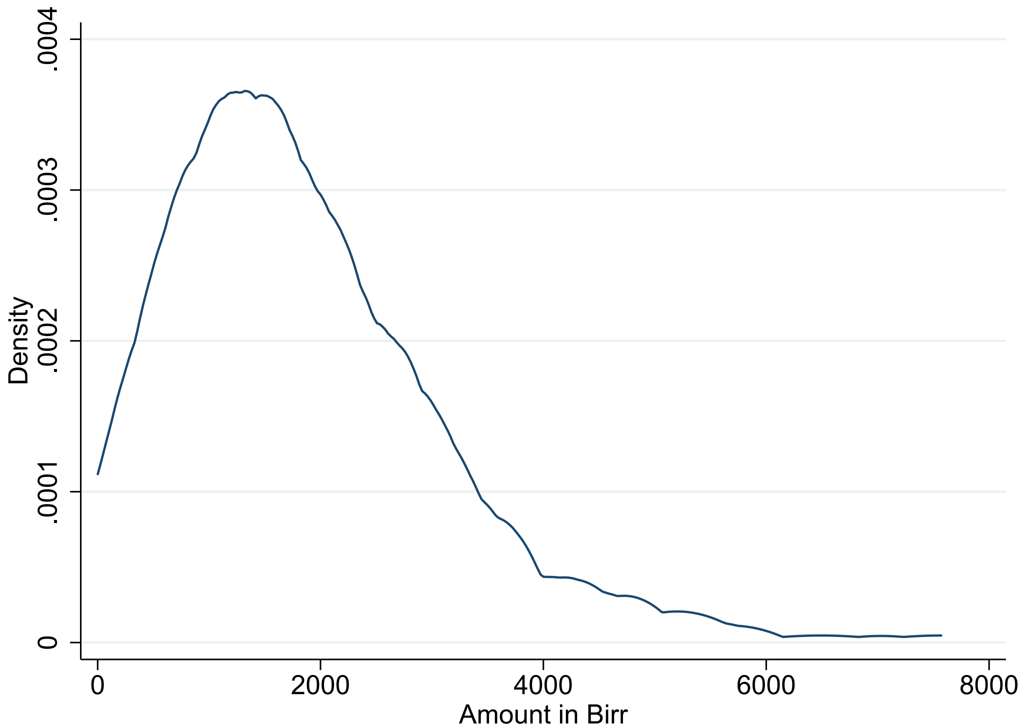
Table B.10: *LATE results of microcredit loan on per hectare input changes*

	Labor sharing days (1)	Family labor days (2)	Hired labor days (3)	Total labor days (4)	Fertilizer expenditure (ETB) (5)
Fuzzy-DID results					
Wald-DID	-0.089	-0.196	0.043	-0.310	0.599
	(0.140)	(0.217)	(0.126)	(0.211)	(0.292)**
Wald-TC	-0.101	-0.214	0.056	-0.324	0.628
	(0.143)	(0.220)	(0.129)	(0.215)	(0.299)**
Local Average Treatment Effects	-0.146	0.124	0.205	0.003	0.661
	(0.135)	(0.134)	(0.112)*	(0.123)	(0.341)*
N	2,941	2,941	2,941	2,941	2,941

Note: *** $p < 0.01$ ** $p < 0.05$ * $p < 0.10$.
Fuzzy DID results consider the microcredit treatment switching groups which potentially influences the Local Average Treatment Effects of the microcredit on the labor and input allocation. Treatment group is those who received microcredit but did not benefit in the previous round and control group is who already received microcredit from previous year or dropped out from previous loan take-up. All estimations were replicated 1,000 times using the Bootstrap to compute the standard errors.

B.6 Loan amount distribution

Figure B.2: *Microcredit amount distribution*



Source: Ethiopian Rural Household Survey