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Credit Constraints, Agricultural Productivity and Household Welfare in Burkina Faso: A Gender-Based Perspective

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Abstract

In this paper, we investigate how different types of credit constraints affect male and female farmers' household welfare. Because credit constraints are endogenous and their effects are expected to depend on farmers' characteristics, we specify an endogenous switching regression model. We define three credit constraint levels (high, medium and low) based on household survey data from Burkina Faso (MICS 2014) and verify the effects of non-linear credit constraints on women's welfare. More specifically, relaxing credit constraints on male farmers from a high constraint level to a medium one increases per capita consumption by about 6%, whereas female farmers experience a non-significant effect. Full relaxation from a medium constraint level to a low one improves men's welfare by another 6%, whereas women exhibit a non-linear improvement of about 12%. We find evidence that the welfare improvement may be the result of credit diversion from agricultural productivity loans.

Keywords: Household production, credit constraints, agriculture, welfare, gender
JEL Classification: D13; Q14; E21.

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1 Introduction

Agriculture is one of the key sectors driving economic growth in Sub-Saharan Africa and, as many authors have pointed out, agricultural growth-enhancing policies are likely to be the most effective at reducing poverty compared to those of other sectors (de Janvry and Sadoulet, 2010; Christiaensen et al., 2011). In agriculture, productivity improvements are determined by the ability to access a variety of resources, yet the literature identifies a systematic gender-based productivity gap that favors men and raises questions regarding the gender gaps in access to resources (Goldstein and Udry, 2008a; Akresh, 2005; wa Gĩthĩnji et al., 2011; Slavchevska, 2015). In this regard, Morsy (2020) finds that women across countries and sectors suffer the most from financial constraints, while Malapit (2012) provides evidence of such a gap in the Philippines's agricultural sector. Because access to credit is fundamental to smooth consumption by vulnerable farm households (Ali et al., 2014; Wik, 1999), a gender gap in access to credit is likely to induce a gender-based welfare gap. Furthermore, when credit access is considered a binary status (full access or no access), as is the common practice in the literature, it hides the potential heterogeneous effects that different degrees of access to credit may have on productivity and welfare.

In this paper, we seek to identify how different types of credit constraints affect male and female farmers' household welfare. Because such effects could be channeled through agricultural productivity, we also identify the credit constraints' effects on households' plot yields. In order to fine-tune the potential policy implications of easing credit constraints, we distinguish between three credit constraint intensity levels: low, medium and high. We define highly credit constrained individuals as the ones in need of credit who remove themselves from the credit market because of their small endowments. Medium credit constrained individuals are in need of credit and participate in the credit market but do not get credit. Finally, low credit constrained individuals are in need of credit, participate in the credit market and get credit.

Our empirical analysis builds on Burkina Faso's nationally representative sample survey from the 2014 Multisectoral Continuous Survey (MICS 2014). We focus on welfare and productivity improvements by estimating the average treatment effects on the treated (ATET) and untreated (ATU) subpopulations, from a regression-based approach. In this setup, it can easily be argued that credit constraints are not exogenous to either welfare or households' farm productivity. We address this concern by estimating a multinomial tobit model – a generalization of an endogenous switching regression – where our three credit constraint intensity levels define three endogenous welfare and productivity regimes. The causal effect of the endogenous credit constraint level is identified through model non-linearities. Nevertheless, in order to improve empirical identification, we explore the literature on social capital, according to which households' social networks determine access to credit (Ali et al., 2014). This makes it possible to identify suitable exclusion restrictions whose exogeneity and weakness are formally tested by means of an auxiliary linear model under an instrumental variable estimation framework. More specifically, we rely on membership in an association or a decision-making body of an association and the level of network inclusion at the department level as exclusion restrictions (Grootaert et al., 1999).

We verify that credit constraints reduce per capita consumption, more specifically, that improving credit constraints for male farmers from HCC (highly credit constrained) to MCC (medium credit constrained) increases per capita consumption by about 6% (USD 51), and improving them from MCC to LCC (low credit constrained) increases welfare by an additional 6%. In the case of women, credit constraint relaxation improves welfare only when transitioning from MCC to LCC, and the welfare gain is about 12% or USD 46. The agricultural productivity analysis unveils positive productivity effects for male farmers but negative ones for female farmers, thus providing evidence of credit diversion.

This paper contributes to the literature by identifying channels that explain the heterogeneous gender effects of access to credit on welfare and productivity and proposing the existence of three credit constraint intensity levels that exhibit non-linear effects on welfare and productivity. This allows for more policy-relevant implications of potential credit access easing interventions. More specifically, non-linear effects are identified in the case of women, whose welfare gain is statistically significant only when transitioning from MCC to LCC. From the dissonance between women's welfare improvement and stagnant productivity (when transitioning from MCC to LCC), we contribute to the literature by providing evidence of credit diversion.

The rest of the paper proceeds as follows. Section 2 discusses the research context and the methodology. Section 3 provides some descriptive statistics. In Section 4, we show the results and discuss the productivity and credit diversion channels. Section 5 concludes the paper.

2 Background

Agriculture accounts for about a third of Burkina Faso's GDP, and the country's employed labor force is mostly concentrated in agriculture (90% of the workforce in 2012).[1] The most important government policy program for the agricultural sector, the National Program for the Rural Sector (PNSR), was first implemented for the 2011-2015 period. The program is currently in its second phase (PNSR II, 2016-2020) and focuses mainly on food security, improving rural populations' revenues and the sustainability of natural resource use. In terms of access to funding, the World Bank lent 100 million USD in 2019 under the *Financial Inclusion Support Project* (FISP) to support Burkina Faso's financial inclusion efforts as targeted by its *Politique Nationale pour le Développement Economique et Social* (PNDES). The FISP focuses mainly on the constraints faced by women and women-led enterprises.

Despite growing evidence emerging regarding the relationship between the role of women in agriculture and productivity in many countries, little is known about Burkina Faso, where the majority of people, particularly those in rural areas, are in the agriculture sector and poor. The work of Udry et al. (1995) focusing on Burkina Faso's agricultural sector shows that there are significant inefficiencies in production factor allocation across plots managed simultaneously by household members. They found that there is room for productivity gains of about 10%-15%. Combary and Savadogo (2014) explain some of the inefficiencies in Burkina Faso's cotton sector, relating them to a drop in total factor productivity, which is also likely to explain inefficiencies in other crops.

Kazianga and Wahhaj (2013) apply an intra-household resource allocation model to a social institution that is specific to certain ethnic groups in Burkina Faso. In this institution, the household head (usually a man) has a particular obligation to provide for the entire household using the proceeds from the common plot. The authors found that farm plots managed by male household members use family labor more intensively and achieve higher yields on average than those managed by female household members from the same household. However, no such gender difference exists among private plots. Croppenstedt et al. (2013) suggest that women are not worse farmers than men in a technical sense. Instead, they argue that women often face constraints in their access to and demand for production inputs, which in turn impact their farms' yields.

[1] Country Fact Sheet on Food and Agriculture Policy, 2014, Food and Agriculture Policy Decision Analysis (FAPDA), FAO.

In Burkina Faso, women are likely to face more severe constraints in credit markets, inhibiting all kinds of investment. Women may also have less secure land use rights, whether or not the land is owned by their family (Kazianga and Masters, 2002). Similarly, Haider et al. (2018) find that the likelihood of fertilizer adoption is significantly lower among female plot managers in Burkina Faso than their male counterparts.

In this study, the gender dimension is accounted for by comparing the welfare and productivity of female and male farmers at different constraint levels. This makes it possible to obtain some comparative statistics and nurture financial inclusion policies targeting women.

3 Conceptual framework

Unlike the literature that focuses on measuring credit constraints on a dichotomous scale, our approach seeks to identify welfare and productivity outcomes at different credit constraint levels. This is more informative for policy-making purposes, as it acknowledges the existence of certain degrees of lack of access to credit that could be better addressed by level-specific policy interventions. In this vein, Kuntchev et al. (2012) suggest a framework with a broad concept of credit constraints that includes four levels ranging from Fully Credit Constrained (FCC) to Not Credit Constrained (NCC). This approach was developed to analyze the World Bank's SME surveys and considers firms that do not need credit as "not credit constrained." We argue that these firms' credit (supply) constraints may remain censored because of their abundant capital. Thus, such a taxonomy may not be very informative in a policy-making context that seeks to better target the population in greater need of credit.

Furthermore, most of the available studies on the role of gender in agriculture point to gender inequalities in endowments as a main driver of agricultural productivity gaps. There is evidence that women lack access to land and agricultural inputs, but they also have limited or no access to credit. They are therefore less likely to invest in land and more advanced technologies, on top of facing some other institutional or traditional constraints (Morsy, 2020; Horrell and Krishnan, 2007; Quisumbing, 1996; Tiruneh et al., 2001; Udry et al., 1995).

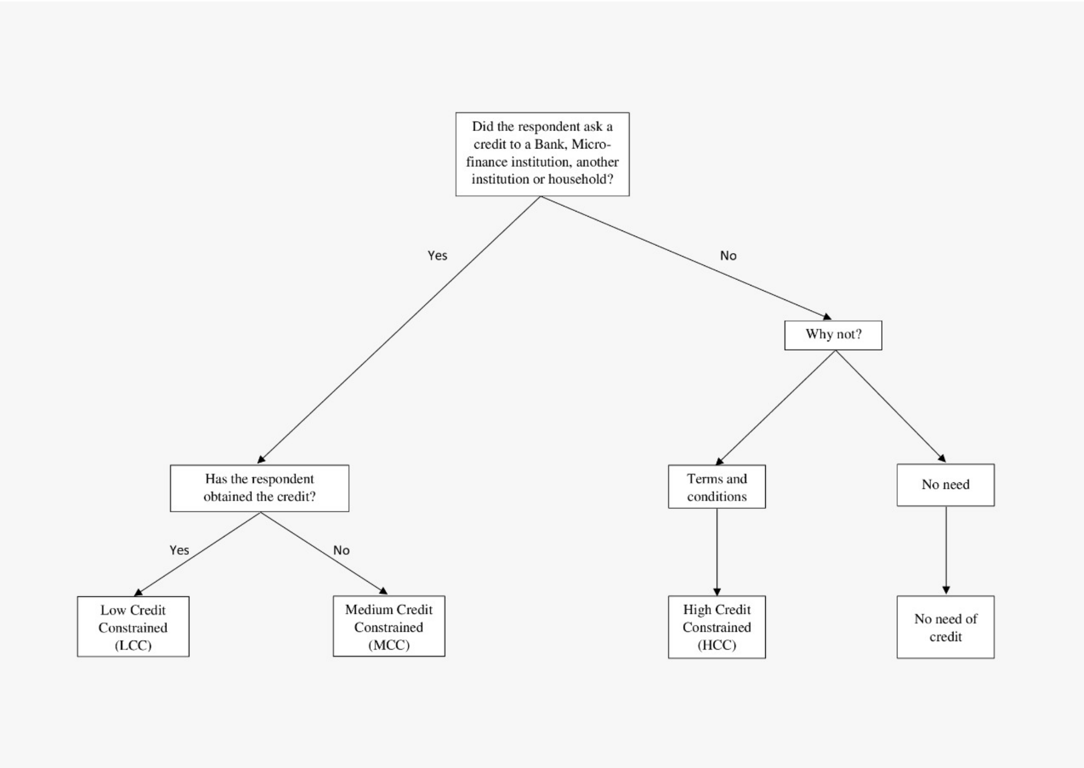
Hence, we distinguish three constraint levels depending on farmers' endowments and the minimum endowment required to gain access to some credit (c_j). While the credit constraint level is denoted by $R \in \{0, 1, 2\}$, farmer endowments are denoted by S^*. As mentioned earlier, our research question focuses on the population of farmers who are vulnerable to credit constraints, i.e., farmers who are in need of credit:

$$\text{Credit Constraint (R)} = \begin{cases} \text{0 - Low Credit Constraint (LCC)} & \text{if } S^* > c_2 \\ \text{1 - Medium Credit Constraint (MCC)} & \text{if } c_1 < S^* \leq c_2 \\ \text{2 - High Credit Constraint (HCC)} & \text{if } S^* \leq c_1 \end{cases} \tag{3.0}$$

We denote the most credit constrained farmers as Highly Credit Constrained (**HCC**). They remove themselves from the credit market because they believe their endowments S^* do not meet the most basic requirements for potential credit c_1, i.e., $S^* < c_1$. Farmers who meet the minimum requirements and therefore decide to apply for credit ($S^* > c_1$) may not fulfill further financial institution requirements ($S^* < c_2$), which should in turn lead to credit refusal. We denote these farmers as Medium Credit Constrained (**MCC**). Finally, those farmers who applied for credit ($S^* > c_1$) and got it ($S^* > c_2$) are considered Low Credit Constrained (**LCC**). Figure 1 illustrates this taxonomy using variables that are available in Burkina Faso's household survey.

Since credit constraints on farmers who do not need credit are typically not the focus of policy interventions, we exclude these farmers from our analysis. However, in the next section, this group is incorporated in the econometric model to perform a robustness check for potential sample selection bias that might result from its omission.

Figure 1: Different types of credit constraint based on individual-level questions



Gender and welfare

Access to credit can help smooth household consumption over time in the case of income fluctuation due to negative shocks. However, the impact of credit access on household consumption could change depending on the gender of the household income contributor. Studies have shown some gender differences in the household consumption function. For instance, Bhupal and Sam (2014) and Pitt and Khandker (1998) found that female income significantly increases household consumption, especially the share of children's clothing and footwear consumption. Pahl (1990) suggests that men contribute more to the domestic economy than women do in absolute terms, but women contribute a higher proportion of their income in relative terms. In the context of this study, we assume gender-related coefficient differences between selection, consumption and productivity equations. Hence, each equation is estimated for men and women.

The agricultural productivity channel

One channel by which credit constraint impacts household welfare in rural areas is agricultural productivity. Many studies provide evidence of imperfect risk-sharing within households and inequality of access to the same technology and the same quality of inputs between men and women (Morrison, 2007; Dercon and Krishnan, 2000; Duflo and Udry, 2003; Dubois and Ligon, 2009). So, given that women have smaller initial endowments and less technical knowledge, credit access could help them invest in higher-quality inputs and therefore improve productivity.

Farmers may apply for credit for reasons other than to purchase agriculture inputs. While some of them may request credit to develop an existing business or purchase equipment, others might do so to fund education or health expenditures, or rather, festival expenditures. In order to account for this heterogeneity in farmers' motives for applying for credit, we estimate three models. The first model includes all observations, regardless of the motives for applying for credit. The second model includes farmers who request credit to purchase productive equipment (be it agricultural or not) or agriculture inputs. The third model includes only farmers who have contracted credit to purchase agricultural inputs.

4 Econometric model

In this section, we discuss the empirical approach for examining the impact of credit constraints on farmers' welfare. We focus on gender heterogeneity and deal with endogeneity concerns. The proposed specification is a multinomial endogenous switching regression model.

Model specification

To model the effects of credit constraints on the welfare and productivity of household farmers in need of credit, the econometric specification must address potential endogeneity with respect to credit constraints. The presence of unobservables such as unobserved abilities and endowments may simultaneously ease credit constraints and enhance welfare and productivity. As mentioned earlier, the model must also account for three constraint levels (R): LCC (0), MCC (1) and HCC (2).

The i-th farmer endowment (S_i^*) is assumed to be a latent function of x_i, a vector of individual characteristics (age, gender, education, relationship to the household head, etc.), household head socio-demographic characteristics (age, gender, education, etc.) and plot characteristics (type of soil, protection mode, type of relief, plot distance from the farmer's home):

$$S_i^* = \tilde{\beta}'\tilde{x}_i + \mu_i \tag{4.1}$$

where $\tilde{x}$ is a vector of exogenous variables that includes a vector of exclusion restrictions (z_i) that determine selection for a credit constraint regime and have no effect on our outcomes of interest: $\tilde{x}_i' = [x_i' \; z_i']$. The choice of exclusion restrictions is discussed at the end of this section. Unobservable characteristics are denoted by the random term μ_i. Thus, a farmer is mapped to a given credit constraint level (R) according their endowment S_i^* and minimum credit requirements (c_1 and c_2). Similarly, our outcomes of interest (household consumption or farm productivity) at the r-th credit constraint C_{ir} depend on exogenous characteristics x_i and unobservables (ϵ_{ir}) that might correlate with endowments' unobserved determinants (μ_i). Since we observe only farmers of a given constraint level, we get a system of mutually exclusive outcome regimes:

$$C_i = \begin{cases} C_{i0} = \gamma_0' x_i + \epsilon_{i1} & \text{if } S_i^* > c_2 \\ C_{i1} = \gamma_1' x_i + \epsilon_{i2} & \text{if } c_1 < S_i^* < c_2 \\ C_{i2} = \gamma_2' x_i + \epsilon_{i3} & \text{if } S_i^* < c_1 \end{cases} \tag{4.1}$$

This specification can be described as a three-regime endogenous switching regression model. It results from the generalization of the endogenous switching regression model specified in the work of Maddala and Nelson (1975). It can also be described as a multinomial tobit model (Lee, 1993). By assuming a multivariate normal distribution of the vector $[\epsilon_{i1} \; \epsilon_{i2} \; \epsilon_{i3} \; u_i]$, the model's two sets of equations, selection and main outcomes, can be estimated by a full-information maximum likelihood (FIML) approach. Because the regimes are mutually exclusive, the correlations between ϵ_{ir} and $\epsilon_{ir'}$ are not defined. The endogenous sorting into a given credit constraint level leads to a positive correlation between ϵ_{ir} and μ_i as the unobserved skills having a direct positive effect on welfare (household consumption) are also expected to positively affect farmers' endowments (S^*).

Although the model's non-linearities ensure the theoretical identification of the FIML parameters (Lokshin and Sajaia, 2004), the presence of exclusion restrictions may enhance identification of the estimated parameters. The literature provides more parsimonious two-step methods that allow for the estimation of each regime's equation individually, but these are known to be not fully efficient (Lokshin and Sajaia, 2004). We obtain an FIML estimator by means of Stata's conditional mixed process (CMP) package developed by Roodman (2011).

Conditional expectations and treatment effects

Our endogenous switching regression model makes it possible to estimate counterfactual welfare (consumption) for a given credit constraint regime ($R = r$). Following Chiburis and Lokshin (2007) , we define conditional expectations and treatment effects as follows:

$$E(C_{ir}|x_i, R_i = r, x_i, z_i) = x_i'\gamma_r + \rho_r\sigma_r\lambda_{ir} \tag{4.2}$$

Where λ_{ir} is defined as:

$$\lambda_{ir-1} = \frac{\phi(c_{r-1} - \tilde{\beta}'\tilde{x}_i) - \phi(c_r - \tilde{\beta}'\tilde{x}_i)}{\Phi(c_r - \tilde{\beta}'\tilde{x}_i) - \Phi(c_{r-1} - \tilde{\beta}'\tilde{x}_i)} \tag{4.3}$$

where $\phi()$ and $\Phi()$ denote the normal density and cumulative distribution functions, respectively. The r-th regime error term (ϵ_r) variance is denoted by σ_r^2, whereas ρ_r represents its correlation with the unobserved endowments.

The three regimes make it possible to assess three average treatment effects on the treated (ATET). The first compares the low credit constrained (LCC or R=0) sample's observed consumption to their counterfactual had they been medium credit constrained (MCC or R=1). This effect is noted as the average treatment effect on the LCC sample with respect to a medium credit constraint (MCC) level or $ATET_{MCC \to LCC}$ and is defined as:

$$ATET_{MCC \to LCC} = \bar{C}_{0,i} - E(C_{1i}|x_i, R_i = 0, z_i) \tag{4.4}$$

where $\bar{C}_{0,i}$ is the expected per capita consumption of the i-th LCC individual. The second term on the right-hand side denotes the expected consumption of the same subpopulation (LCC or R=0) had they been medium credit constrained (MCC).

Similarly, the welfare improvement of the LCC (R=0) sample with respect to their HCC (R=2) counterfactual is denoted by $ATET_{HCC \to LCC}$ and defined as:

$$ATET_{HCC \to LCC} = \bar{C}_{0,i} - E(C_{2i}|x_i, R_i = 0, z_i) \tag{4.5}$$

Finally, the expected welfare improvement of the MCC subpopulation with respect to their HCC counterfactual can be written as:

$$ATET_{HCC \rightarrow MCC} = \bar{C}_{1,i} - E(C_{2i}|x_i, R_i = 1, z_i) \quad (4.6)$$

These three ATET expressions make it possible to identify the welfare improvements for the LCC and MCC subpopulations with respect to more severe credit constraint levels. We also present the average treatment effects on the untreated as a means of estimating the potential benefits of interventions on the credit constrained subpopulations.

Identification strategy

Even though empirical identification can be achieved through the model's non-linearities, we improve it by introducing exclusion restrictions (z_i). Following Ali et al. (2014), we argue that social networks may improve households' access to information and thus access to credit. In practice, the z_i vector includes three indicators related to a household's social networks and access to information.

The first indicator is the number of household members who are part of an association. The greater the number of people in a household who are members of an association, the greater the probability that the household has access to information about accessing credit. The second indicator is the number of household members who are members of a decision-making body of an association. Because this indicator refers to a decision-making body, it may be a better proxy of access to credit information through an association. The third indicator is the proportion of households in the department[2] that have a person who is a member of an association. Even though this is a regional indicator, it is computed at the household level as the ratio of the number of households that include (at least) one member of an association, excluding the current household, to the total number of households in the department, minus the current household. This instrument measures the potential that a given household access credit information from its neighbors (department).

However, our model faces the potential endogeneity of the credit constraint status with respect to household consumption, our outcome of interest. It may be easily argued that unobservable characteristics such as unobserved skills may affect both household consumption and access to credit. On one hand, farmers

[2] Burkina Faso's provinces are divided in 351 departments or "communes."

may be sorted by credit institutions based on gains, meaning the most productive are more likely to be granted access to credit. On the other hand, more skilled farmers are expected to procure themselves higher levels of well-being irrespective of their credit constraint status. In the context of an instrumental variable (IV) estimation, our exclusion restrictions can be interpreted as instruments that are expected to be correlated to the credit constraint indicator but should not be correlated to consumption (orthogonality assumption). To explore the validity of the latter assumption, we estimate an auxiliary model where credit constraints (R) enter the consumption equation as a continuous regressor. This makes it possible to test the validity of our instruments in terms of their weakness (correlation with the endogenous regressor) and orthogonality with respect to the main equation residual term. We implement the more efficient GMM IV estimator available in Stata's IVREG2 and perform the overidentification exclusion test. Standard errors are clustered at the farmer level for the regression on plot yield.

5 Data and descriptive statistics

We use data from Burkina Faso's MICS 2014. MICS is a nationally representative survey that includes information from both the household and the individual level. In total, 10,800 households were surveyed. In addressing this study's research question, the study sample was restricted to agricultural households representing 7,410 households overall. MICS 2014 collected detailed information about agricultural activity such as production, the use of inputs and plot characteristics. The survey also includes a detailed module on household consumption and other sections on household characteristics, the socio-demographic characteristics of members, credit and savings, etc.

The less constrained farmers are, the more capital they have

Table 1 presents the socio-demographic characteristics of farmers and landowners by credit constraint status. It appears that MCC and LCC farmers are different from HCC farmers in many ways. In terms of socio-demographic characteristics, LCC and MCC farmers are likely to be younger, male and married. Furthermore, they appear to have access to larger social networks than their HCC peers. The proportion of MCC or LCC farmers who have a member of an association in their household is higher than that of HCC farmers. Furthermore, LCC farmers seem wealthier and more endowed in terms of human capital compared to the other two farmer groups, while MCC and HCC farmers don't seem different regarding their average per capita consumption or their education. These relationships are consistent with the intuition that the more capital farmers have, the less they are financially constrained.

Moreover, it is worth noting differences in the characteristics of farmers and landowners, suggesting that farmers don't systematically own the plots they work. While farmers and landowners may seem to have on average the same level of education and a similar likelihood of having a member of an association or a decision-making body of an association in their household, they are different in terms of age, sex and link to the household head. Landowners are more likely to be older, male and household heads. In fact, regardless the level of credit constraint, land owners are mostly male, household heads and relatively older compared to farmers. This points to unequal access to land ownership, with female and younger farmers being worse off.

Plot characteristics, management mode and input use are different between the three groups

The fact that MCC and LCC farmers are better off might be explained by differences in the farming practices and type of inputs used in the plots (Table A1). Both MCC and HCC farmers tend to manage their plots collectively, while LCC farmers adopt a more individual management mode. This suggests that MCC and HCC farmers tend to pool their resources to maximize their output and share the various economic risks.

Furthermore, MCC and LCC farmers seem to have more access to better inputs than HCC farmers. The latter use more garbage as fertilizer on average, whereas MCC and LCC farmers use more chemical fertilizers and phytosanitary products. HCC farmers are also less likely to use storage techniques compared to their MCC and LCC peers. The cost of these inputs may explain their high use by MCC and LCC farmers, as they appear to be wealthier compared to HCC farmers.

Plot characteristics by gender

The same patterns are observed when the sample is broken down into male and female farmers. The management mode of male and female farmers appears generally similar to the overall pattern (Table A1). LCC male and female farmers are likely to manage their plot individually, whereas their HCC and MCC counterparts adopt collective management practices. We observe also that LCC male and female farmers are likely to use chemical phytosanitary products as inputs. In addition, LCC farmers seem to have more access to better inputs and use more storage techniques than HCC farmers regardless of gender. This suggests that the cost of inputs may represent an important constraint that doesn't depend on gender. Both female and male HCC farmers may not have enough resources to access better inputs.

Table 1: Socio-demographic characteristics of farmers and landowners by credit constraint status

	High			Medium			Low			Medium - High		Low - High	
	Mean	Sd	Obs.	Mean	Sd	Obs.	Mean	Sd	Obs.	Mean	t-stat	Mean	t-stat
Farmer characteristics													
Socio-demographic characteristics													
Age	46.0	16.3	3613	43.0	14.8	1435	44.4	13.2	1578	-3.0	-6.4***	-1.6	-3.8***
Female	0.4	0.5	3613	0.3	0.5	1435	0.2	0.4	1578	0.0	-1.3	-0.2	-16.2***
Married	0.9	0.3	3610	0.9	0.3	1434	0.9	0.3	1577	0.0	3.1***	0.1	6.3***
Link with household head													
Head	0.7	0.5	3613	0.7	0.5	1435	0.9	0.3	1578	-0.02	-1.6*	0.2	-1.6*
Spouse of the head	0.2	0.4	3613	0.2	0.4	1435	0.1	0.2	1578	0.0	0.8	-0.1	0.8
Other	0.1	0.3	3613	0.1	0.3	1435	0.0	0.1	1578	0.0	1.4	-0.1	1.4
Education													
No education	0.9	0.3	3582	0.9	0.3	1423	0.9	0.3	1554	0.0	1.8*	0.0	-1.6*
Primary	0.1	0.3	3582	0.1	0.2	1423	0.1	0.3	1554	0.0	-2.2**	0.0	0.9
Secondary and higher	0.0	0.2	3582	0.0	0.2	1423	0.0	0.2	1554	0.0	0.2	0.0	1.5
Social networks													
Association membership (YES)	0.2	0.4	3586	0.2	0.4	1433	0.4	0.5	1574	0.0	1.4	0.2	12.9***
Decision-making body of an association (YES)	0.3	0.5	726	0.3	0.4	325	0.4	0.5	603	-0.1	-1.7*	0.1	2.6***
Land owner characteristics													
Socio-demographic characteristics													
Age	48.6	16.2	2354	46.8	14.8	837	45.0	13.2	1142	-1.8	-3.0***	-3.6	-7.1***
Female	0.2	0.4	2354	0.1	0.4	837	0.1	0.3	1142	-0.1	-6.0***	-0.1	-10.0***
Married	0.9	0.3	2354	0.9	0.3	836	0.9	0.3	1141	0.0	1.9**	0.0	3.9***
Link with household head													
Head	0.8	0.4	2354	0.9	0.3	837	1.0	0.2	1142	0.1	4.7***	0.1	13.0***
Spouse of the head	0.1	0.3	2354	0.1	0.2	837	0.0	0.2	1142	-0.1	-4.8***	-0.1	-11.1***
Other	0.0	0.2	2354	0.0	0.2	837	0.0	0.1	1142	0.0	-1.2	0.0	-6.2***
Education													
No education	0.9	0.3	2333	0.9	0.3	834	0.9	0.3	1126	0.0	2.2**	0.0	-0.3
Primary	0.1	0.3	2333	0.1	0.2	834	0.1	0.3	1126	0.0	-2.8***	0.0	0.6

Table 1 (continued) Socio-demographic characteristics of farmers and landowners by credit constraint status

	High			Medium			Low			Medium - High		Low - Medium	
	Mean	Sd	Obs.	Mean	Sd	Obs.	Mean	Sd	Obs.	Mean	t-stat	Mean	t-stat
Secondary and higher	0.0	0.2	2333	0.0	0.2	834	0.0	0.1	1126	0.0	0.4	0.0	-0.5
Social networks													
Association membership (YES)	0.2	0.4	2347	0.2	0.4	837	0.4	0.5	1139	0.0	1.7*	0.2	10.8***
Association membership (% district population)	0.2	0.30	3611	0.2	0.30	1435	0.30	0.35	1578	.0	1.1	0.1	10.7***
Decision-making body of an association (YES)	0.3	0.5	485	0.3	0.5	205	0.4	0.5	445	0.0	-0.7	0.1	2.4**
Household welfare													
Deflated consumption per capita (thousands FCFA)	190.4	105.8	3613	193.5	106.7	1435	217.8	122.5	1.6	3.1	0.9	27.4	7.7***
Poverty incidence	0.4	0.5	3613	0.4	0.5	1435	0.4	0.5	1.6	0.0	-0.7	-0.1	-6.6***

* p<0.1 ** p<0.05 *** p<0.01

Source: EMC 2014, Agricultural household sample, authors' calculations

6 Results

In this section, we first test the validity of our exclusion restrictions within an IV estimation framework. We then present and discuss the results of the multinomial switching regression model in light of the channels that drive the relationship between credit constraints and household welfare.

Social networks as a proper exclusion restriction

Even though our main model is non-linear, we implement a linear version of it by requiring the credit constraint indicator to be continuous. This makes it possible to test our exclusion restrictions as if they were instrumental variables. More specifically, we test their weakness and orthogonality conditions. Once tested, the exclusion restrictions (z_i) are included in the definitive non-linear multinominal switching regression model.

Table A1 presents the diagnostic test results of our IV (GMM) estimator where the household consumption equation is a function of a continuous credit constraint endogenous regressor. Given that we have three instruments, we can test for orthogonality between our chosen instruments and the main equation residual term. The implied Hansen test does not reject the null of orthogonality, which confirms that the IV estimator is likely to be asymptotically consistent in the presence of the potential endogeneity of the credit constraint with respect to our welfare outcome. This supports the weak exogeneity of our exclusion restrictions, which we introduce to improve the empirical identification of the multinomial switching regression model.

An IV estimator could be biased in the presence of a weak relationship between the endogenous regressor and our instruments. Table A3 shows a significant positive correlation between the instruments and the credit constraint indicator. A formal test is provided by the Cragg-Donald F statistic that suggests that our instruments are not weak compared to Stock-Yogo weak identification critical values (Table A1). This verifies the social capital argument that having a person in the household who is a member of an association or living in a district where there are many associations helps farmers improve their access to credit.

The effects of credit constraints on household welfare

Table 2 presents the average treatment effects (ATET and ATU) of the different credit constraint levels on per capita household consumption by gender. Whereas the ATET is informative of ex-post welfare improvement, the ATU is informative of ex-ante potential improvement, i.e., while the former assesses the outcome of an observed intervention on a treated subpopulation, the latter assesses the potential improvement that would result from a policy intervention on an untreated subpopulation.

To assess the robustness of our findings, we present three alternative estimators in Table 2. The first calculates the ATET and ATU from our multinomial switching regression model. The second one – in the ATET(s) and ATU(s) columns – provides a robustness check estimation that corrects for potential sample selectivity bias induced by the omission of the subpopulation that does not need any credit.[3] This correction is easily implemented by adding an auxiliary probit equation that models the need for credit as a function of exogenous characteristics. The third presents the ATET and ATU in US dollars instead of their log scale.

In the case of men, both the ATET and ATU report similar magnitudes, which suggests that individuals exhibit homogeneous characteristics across credit constraint statuses. The slight discrepancy between the ATET and ATU estimates and their sample selection bias corrections (the ATET(s) and ATU(s) columns) is explained by the low correlation between the unobservables that determine the need for credit and the unobservables in the welfare equation. A hypothetical transition or intervention that pushes individuals from HCC to MCC status is expected to improve welfare by about 4% per the ATU(s). Similarly, a hypothetical transition from MCC to LCC status would improve welfare by about 4.4% (ATU(s)). The analog ex-post improvement between HCC to MCC status and between MCC to LCC status is about 6% in each case per the ATET(s).

In the case of women, we notice a greater discrepancy between the standard estimates and their sample selection bias corrections, mainly in the ATU. This may be interpreted as the consequence of common unobserved heterogeneity factors determining both welfare and the need for credit. Focusing on the corrected estimates – the ATET(s) and ATU(s) – shows that unlike men, women exhibit a non-linear improvement in welfare as credit constraints relax. Both estimators point to a non-statistically significant improvement when transitioning from HCC to MCC status, whereas a transition from MCC to LCC status leads to a sharp 12% increase in welfare.

[3] Although the estimation equations are not included in this paper for the sake of presentation, they are available from the authors upon request.

Table 2: Treatment effects of credit constraints on the logarithm of per capita consumption

Gender	Treated sample	Untreated	ATET	ATET (s)	ATET ($)	N	ATU	ATU (s)	ATU ($)	N
Men	LCC	MCC	0,05***	0,06***	49,60	1321	0,05***	0,044***	42	944
	LCC	HCC	0,09***	0,1***	84,41	1321	0,11***	0,11***	94	2308
	MCC	HCC	0,06***	0,06***	51,47	944	0,05***	0,04***	42	2308
Women	LCC	MCC	0,15***	0,12***	132,91	257	0,06***	0,12***	46	491
	LCC	HCC	0,09***	0,08***	85,59	257	0,09***	0,15***	78	1306
	MCC	HCC	0,05**	0,02	35,18	491	-0,03***	0,01	(29)	1306

Note: * p<0.1 ** p<0.05 *** p<0.01.
ATET Average treatment effect on the treated.
ATU Average treatment effect on the untreated.
LCC Low credit constraint, MCC Medium credit constraint, HCC High credit constraint.
($) Estimate in US dollars.
(s) Estimate corrected for sample selection bias due to the omission of farmers that do not need credit.

The underlying estimation equations verify some stylized facts (see Table A3). As expected, education improves human capital and therefore per capita consumption across the three regimes. However, such improvement is less pronounced in the case of women, who get positive returns only on primary education.

The selection equation provides an estimate of the latent endowments S^* that determine access to credit. From the linear and quadratic age coefficients, we find that experience may improve farmers' endowments and access to credit up to a certain age, after which experience may become obsolete or their physical condition may penalize their productivity performing farming activities. We estimate the age at which endowments peak to be 36 and 35 years old for men and women, respectively.

As for the types of soil, clay has the highest positive effect on endowments irrespective of gender. The dependency ratio increases latent endowments, as not only the adult household members contribute to the farm labor force.

Our exclusion restrictions, which are a proxy of available social networks, are statistically significant. More specifically, being a member of an association has a positive effect on both men's and women's endowments, although the effect for women is twice that for men (0.28 vs 0.52). Similarly, the share of people in the district who are members of an association, which is a proxy of the effects of the regional social network, has a significant effect only on women's endowments.

The potential endogeneity of the credit constraint with respect to consumption is verified by the statistically significant conditional correlations in the case of women.

The agricultural productivity channel and credit diversion

Welfare improvements due to productive credit constraint relaxation are expected to be channeled through agricultural productivity enhancements.

To examine the impact of credit constraint on agricultural yield, our empirical analysis builds on the endogenous switching regression model using agricultural productivity as the main outcome instead of consumption. We first analyze farmers who apply for credit to purchase productive equipment or inputs for agriculture or for new business. Next, we analyze the subsample of farmers who request credit to purchase productive equipment or inputs for agriculture. Last, we focus on the subsample of farmers who apply for credit to purchase inputs for agriculture.

Agricultural productivity is measured by output per hectare. An exploratory analysis showed the presence of outlying observations for this productivity indicator; we chose to deal with extreme yields by identifying those that lie above the maximum yields per type of crop set by the General Directorate for Promotion of the Rural Economy (DGPER).[4] Once identified, the extreme yields are truncated to the maximum provided for by the DGPER. Furthermore, crops with fewer than 30 observations in our sample are dropped from the analysis. The different crops' yields are standardized by the average yield of a given type of crop in the overall sample. This implies that our standardized yield indicator has an average value of one irrespective of the type of crop. In Burkina Faso, male and female farmers do not grow the same types of crops. Men usually plant cereals such as maize, millet and rice, whereas women plant market gardening or cash crops such as vegetables, peanuts and beans. Thus, we define two yield indicators. The first considers all crops, whereas the second is specific to cash crops and market gardening (often planted by female farmers).

Regarding men's yield effects for both crops, we identify positive yield effects of credit constraint relaxation when transitioning from MCC to LCC status irrespective of the motive for asking for credit (Table 3). In other words, receiving credit (LCC) exhibits a positive effect on agricultural productivity with respect to asking for credit (MCC). Although this supports the credit productivity channel, we also identify negative effects when transitioning from HCC to MCC status.

Contrary to men, women exhibit statistically significant negative yield effects as they transition from MCC to LCC status. These results are consistent across

[4] The DGPER is a government institution that works to promote agricultural activities and local agricultural products.

two of the three motives for asking for credit, which suggests that credit is diverted towards consumption or alternative economic activities. As a robustness check, we estimate an endogenous switching regression with sample selection bias correction (see Table A6) that verifies the negative yield effects of the standard estimates.

Table 3: Treatment effects of credit constraints on plot yields by gender

	Reason of credit demand	Sample	Statistics	Sample LCC				Sample MCC	
				Counterfactual MCC		Counterfactual HCC		Counterfactual HCC	
				Man	Woman	Man	Woman	Man	Woman
All crops	To purchase productive equipment, agricultural Input, new business	Credit constraint	Mean	1,19	0,83	1,19	0,83	0,97	0,90
			Sd	1,28	1,04	1,28	1,04	1,21	1,15
		Counterfactual	Mean	1,06	0,91	1,05	0,90	1,04	0,96
			Sd	0,23	0,44	0,24	0,37	0,23	0,34
		ATET		0,13***	-0,07	0,14***	-0,07	-0,07***	-0,05
		t-stat		4,50	-0,94	4,84	-0,93	-2,99	-1,07
		N		1892	210	1892	210	2591	514
	To purchase productive equipment and agricultural Input	Credit constraint	Mean	1,20	0,74	1,20	0,74	0,97	0,90
			Sd	1,29	1,04	1,29	1,04	1,21	1,15
		Counterfactual	Mean	1,06	0,96	1,05	0,89	1,04	0,96
			Sd	0,23	0,45	0,24	0,40	0,23	0,34
		ATET		0,14***	-0,22**	0,15***	-0,15*	-0,07***	-0,06
		t-stat		4,53	-2,33	4,91	-1,74	-2,98	-1,09
		N		1797	141	1797	141	2591	514
	To purchase agricultural Inputs	Credit constraint	Mean	1,22	0,75	1,22	0,75	0,97	0,90
			Sd	1,32	1,01	1,32	1,01	1,21	1,15
		Counterfactual	Mean	1,06	0,99	1,05	0,95	1,04	0,96
			Sd	0,23	0,53	0,25	0,41	0,23	0,34
		ATET		0,16***	-0,24**	0,17***	-0,2*	-0,07***	-0,06
		t-stat		4,91	-2,11	5,25	-1,85	-2,97	-1,11
		N		1619,00	91,00	1619,00	91,00	2591,00	514,00
Cash crop and market gardening	To purchase productive equipment, agricultural Input, business	Credit constraint	Mean	1,15	0,90	1,15	0,90	0,90	0,88
			Sd	0,72	0,67	0,72	0,67	0,74	0,69
		Counterfactual	Mean	1,00	1,01	1,07	0,88	1,02	0,87
			Sd	0,22	0,32	0,15	0,26	0,22	0,29
		ATET		0,15***	-0,11	0,08**	0,02	-0,12***	0,01
		t-stat		4,41	-1,25	2,49	0,22	-3,87	0,30
		N		481	78	481	78	549	199
	To purchase productive equipment and agricultural Input	Credit constraint	Mean	1,14	0,74	1,14	0,74	0,90	0,88
			Sd	0,71	0,62	0,71	0,62	0,74	0,69
		Counterfactual	Mean	0,99	1,02	1,07	0,89	1,02	0,87
			Sd	0,21	0,28	0,15	0,27	0,22	0,29
		ATET		0,15***	-0,29***	0,07**	-0,15	-0,12***	0,01
		t-stat		4,24	-2,74	2,22	-1,50	-3,86	0,26
		N		456	50	456	50	549	199
	To purchase agricultural Inputs	Credit constraint	Mean	1,14	0,71	1,14	0,71	0,90	0,88
			Sd	0,71	0,59	0,71	0,59	0,74	0,69
		Counterfactual	Mean	0,98	0,98	1,06	0,92	1,02	0,87
			Sd	0,20	0,26	0,15	0,26	0,22	0,29
		ATET		0,16***	-0,27**	0,08**	-0,21*	-0,12***	0,01
		t-stat		4,27	-2,42	2,27	-1,89	-3,83	0,24
		N		408	38	408	38	549	199

Note: * p<0.1 ** p<0.05 *** p<0.01

We identify two channels that may drive the negative impacts observed for women. First, credit might be diverted towards activities other than agriculture. In rural areas, non-farm income could relieve liquidity constraints for households that engage in multiple activities (Haider et al., 2018). Women from indebted households could divert the credit towards more productive business activities to ensure loan repayment. This change in women's behavior might occur due to imperfect risk sharing within the household (Dercon and Krishnan, 2000; Duflo and Udry, 2003; Dubois and Ligon, 2009; Kazianga and Wahhaj, 2013).

Second, because women have low bargaining power in the household, they are not fully empowered to decide how their credit should be used. They may witness a misappropriation of their credit for other purposes. In addition, inefficiency in the allocation of productive resources within the household (Udry, 1996; Goldstein and Udry, 2008b) may not allow them to use other resources that are available so as to use their credit more efficiently. Also worth mentioning are the differences in property rights in rural areas in general, and especially between men and women in Burkina Faso, where women have limited property rights. This does not allow them to make investments in their plot such as introducing soil and water conservation techniques (Kazianga and Masters, 2002; Theriault et al., 2017).

Credit diversion is not well documented in the literature, most likely because of methodological challenges involved in formally measuring it. Feder et al. (1990), Feder et al. (1992), Khaleque (2011) and Banerjee et al. (2015) provide evidence of the prevalence of this phenomenon in rural regions of China, Bangladesh and India. Our results contribute to this literature with the notable increase in consumption when transitioning from MCC to LCC status, which comes with a negative effect on agricultural productivity.

7 Conclusion

Our findings suggest that credit constraints are harmful to farmers' welfare irrespective of gender. Easing credit constraints results overall in significant household welfare improvement. Switching from HCC to LCC status is expected to increase households' per capita consumption significantly. The welfare improvement is similar as credit constraints are eased for men. As for women, we found non-linear improvement in welfare. A policy intervention that aims to shift female farmers from MCC to LCC status is expected to result in significant welfare improvements, whereas the welfare gain from one aiming to shift them from HCC to MCC status is expected to be zero. These results suggest that enhancing HCC women's endowments to the same level as those of MCC women is insufficient to improve their welfare significantly. Hence, a typical policy that is limited to relaxing terms and conditions to encourage applying for credit may improve men's welfare but seems insufficient to improve women's welfare. This policy must be accompanied by other measures that increase the likelihood of being approved for credit, especially for women.

There is evidence suggesting that the welfare gain effects as a result of easing credit constraints are likely to be driven by agricultural productivity only for male farmers. We find that the agricultural productivity of both MCC and LCC male farmers is significantly higher than that of HCC male farmers. On the contrary, credit constraints have no effect on the productivity of female farmers. A potential explanation is that the credit might be used for other reasons than investing in agricultural productivity. We then delve further in the analysis by looking into the impact of credit constraints based on the motives for requesting credit. If we focus on the subsample of farmers asking for credit for productive reasons, we find that the productivity of MCC and LCC male farmers is still higher than that of their HCC peers. However, we found the reverse for women. MCC and LCC female farmers have significantly lower productivity than their HCC counterparts. We argue that the credit obtained by female farmers might be used for other purposes (new business-like trade) than investing in plot productivity. Furthermore, female farmers might not be the ones making the decisions related to working the plot given they are unlikely to own the land.

This paper highlights how critical of a role credit constraints may play in designing agricultural policies in Burkina Faso. Easing credit constraints translates into improved welfare for farmers. Yet, increased productivity is likely to be a potential mechanism behind this welfare gain only for male farmers. These gender differential effects suggest that enhancing financial inclusion measures should be combined with measures to empower women. A lack of bargaining power and capital constraints (education, land, etc.) represent potential factors that prevent female farmers from making the most of the advantage credit provides for their agricultural activities. Consequently, tackling these obstacles must be considered, and policies that combine access to credit and measures to empower female farmers might be necessary to close the gender-related productivity gap in Burkina Faso.

References

Akresh, Richard, "Understanding Pareto inefficient intrahousehold allocations," 2005.

Ali, Daniel Ayalew, Klaus Deininger, and Markus Goldstein, "Environmental and gender impacts of land tenure regularization in Africa: Pilot evidence from Rwanda," *Journal of Development Economics*, 2014, *110*, 262–275.

Banerjee, Tanmoyee, Malabika Roy, Ajitava Raychaudhuri, and Chandralekha Ghosh, "What drives households to divert loans? A village level study," *Asia-Pacific Social Science Review*, 2015, *15* (2), 33–55.

Bhupal, G. and A.G. Sam, "Female income and expenditure on children: Impact of the national rural employment guarantee scheme in India," *Applied Econometrics and International Development*, January 2014, *14*, 175–192.

Chiburis, Richard and Michael Lokshin, "Maximum likelihood and two-step estimation of an ordered-probit selection model," *The Stata Journal*, 2007, *7* (2), 167–182.

Christiaensen, Luc, Lionel Demery, and Jesper Kuhl, "The (evolving) role of agriculture in poverty reduction—An empirical perspective," *Journal of Development Economics*, November 2011, *96* (2), 239–254.

Combary, Omer S and Kimseyinga Savadogo, "The Sources of Total Factor Productivity Growth in Burkina Faso's Cotton Farms," *Revue d'économie du développement*, 2014, *22* (4), 61–82.

Croppenstedt, Andre, Markus Goldstein, and Nina Rosas, "Gender and Agriculture: Inefficiencies, Segregation, and Low Productivity Traps," *The World Bank Research Observer*, 2013, *28* (1), 79–109. Publisher: Oxford University Press.

de Janvry, Alain and Elisabeth Sadoulet, "Agricultural Growth and Poverty Reduction: Additional Evidence," *The World Bank Research Observer*, February 2010, *25* (1), 1–20.

Dercon, Stefan and Pramila Krishnan, "In Sickness and in Health: Risk Sharing within Households in Rural Ethiopia," *Journal of Political Economy*, August 2000, *108* (4), 688–727. Publisher: The University of Chicago Press.

Dubois, Pierre and Ethan A. Ligon, "Nutrition and Risk Sharing within the Household," SSRN Scholarly Paper ID 1533179, Social Science Research Network, Rochester, NY November 2009.

Duflo, Esther and Christopher Udry, "Intrahousehold Resource Allocation in Cote D'Ivoire: Social Norms, Separate Accounts and Consumption

Choices," SSRN Scholarly Paper ID 427064, Social Science Research Network, Rochester, NY June 2003.

Feder, Gershon, Lawrence J Lau, Justin Y Lin, and Xiaopeng Luo, "The relationship between credit and productivity in Chinese agriculture: A microeconomic model of disequilibrium," *American Journal of Agricultural Economics*, 1990, *72* (5), 1151–1157.

_ , _ , _ , and _ , "The determinants of farm investment and residential construction in post-reform China," *Economic Development and Cultural Change*, 1992, *41* (1), 1–26.

Goldstein, Markus and Christopher Udry, "The profits of power: Land rights and agricultural investment in Ghana," *Journal of political Economy*, 2008, *116* (6), 981–1022.

_ and _ , "The Profits of Power: Land Rights and Agricultural Investment in Ghana," *Journal of Political Economy*, 2008, *116* (6), 981–1022. Publisher: The University of Chicago Press.

Grootaert, C, O Gi-taik, and A Swamy, "Social capital and development outcomes in Burkina Faso. Local level institutions study," *World Bank, Washington, DC, mimeo*, 1999.

Haider, Hamza, Melinda Smale, and Veronique Theriault, "Intensification and intrahousehold decisions: Fertilizer adoption in Burkina Faso," *World Development*, May 2018, *105*, 310–320.

Horrell, Sara and Pramila Krishnan, "Poverty and productivity in female-headed households in Zimbabwe," *Journal of Development Studies*, 2007, *43* (8), 1351–1380. Publisher: Taylor & Francis Journals.

Kazianga, Harounan and William A. Masters, "Investing in soils: field bunds and microcatchments in Burkina Faso," *Environment and Development Economics*, July 2002, *7* (3), 571–591. Publisher: Cambridge University Press.

_ and Zaki Wahhaj, "Gender, Social Norms, and Household Production in Burkina Faso," *Economic Development and Cultural Change*, 2013, *61* (3), 539–576. Publisher: The University of Chicago Press.

Khaleque, Md Abdul, "Diversion of Loan Use-Who Diverts and Why?," *Available at SSRN 1804756*, 2011.

Kuntchev, Veselin, Rita Ramalho, Jorge Rodríguez-Meza, and Judy S Yang, "What have we learned from the Enterprise Surveys regarding access to finance by SMEs," *Enterprise Analysis Unit of the Finance and Private Sector Development, The World Bank Group*, 2012.

Lee, Lung-Fei, "6 Multivariate tobit models in econometrics," in "Econometrics," Vol. 11 of Handbook of Statistics, Elsevier, 1993, pp. 145 – 173.

Lokshin, Michael and Zurab Sajaia, "Maximum likelihood estimation of endogenous switching regression models," *The Stata Journal*, 2004, *4* (3), 282–289.

Maddala, G.S. and Forrest D Nelson, "Specification Errors in Limited Dependent Variable Models," Working Paper 96, National Bureau of Economic Research July 1975. Series: Working Paper Series.

Malapit, Hazel Jean L, "Are women more likely to be credit constrained? Evidence from low-income urban households in the Philippines," *Feminist Economics*, 2012, *18* (3), 81–108.

Morsy, Hanan, "Access to finance : Mind the gender gap," *The Quarterly Review of Economics and Finance*, 2020, *78*, 12 – 21.

Pahl, Jan, "Household spending, personal spending and the control of money in marriage," *Sociology*, 1990, *24* (1), 119–138. Publisher: Sage Publications, Ltd.

Pitt, Mark M and Shahidur R Khandker, "The impact of group-based credit programs on poor households in Bangladesh: Does the gender of participants matter?," *Journal of political economy*, 1998, *106* (5), 958–996.

Quisumbing, Agnes, "Male-female differences in agricultural productivity: Methodological issues and empirical evidence," *World Development*, 1996, *24* (10), 1579–1595. Publisher: Elsevier.

Roodman, D., "Fitting fully observed recursive mixed-process models with cmp," *Stata Journal*, 2011, *11* (2), 159–206(48).

Sinha, Nistha Andrew Raju Morrison Dhushyanth, *Gender Equality, Poverty And Economic Growth* Policy Research Working Papers, The World Bank, November 2007.

Slavchevska, Vanya, "Gender differences in agricultural productivity: the case of Tanzania," *Agricultural Economics*, 2015, *46* (3), 335–355.

Theriault, Veronique, Melinda Smale, and Hamza Haider, "How Does Gender Affect Sustainable Intensification of Cereal Production in the West African Sahel? Evidence from Burkina Faso," *World Development*, April 2017, *92*, 177–191.

Tiruneh, A., T. Tesfaye, W. M. Mwangi, and H. Verkuijl, *Gender differentials in agricultural production and decision-making among smallholders in Ada, Lume, and Gimbichu Woredas of the central highlands of Ethiopia*, CIMMYT, 2001. Accepted: 2012-01-06T05:09:52Z.

Udry, Christopher, "Gender, Agricultural Production, and the Theory of the Household," *Journal of Political Economy*, 1996, *104* (5), 1010–1046. Publisher: University of Chicago Press.

— , **John Hoddinott, Harold Alderman, and Lawrence Haddad**, “Gender differentials in farm productivity: implications for household efficiency and agricultural policy,” *Food Policy*, October 1995, *20* (5), 407–423.

wa Gĩthĩnji, Mwangi, Charalampos Konstantinidis, and Andrew Barenberg, “Small and as Productive: Female-headed households and the inverse relationship between land size and output in Kenya.,” 2011.

Wik, Mette, “Coping with Risk in Agriculture: Income- and Consumption-Smoothing Strategies in LDCs,” *Forum for Development Studies*, 1999, *26* (2), 329–344.

Appendices

A Poverty incidence and credit constraints

Table A.1: Poverty incidence by credit constraint status (%)

	HCC	MCC	LCC	National
Poor	55.4	44.1	51.9	40.1
Not poor	44.6	55.9	48.1	60.9

B Econometric model: further note on error terms

The error terms are assumed to have a quadrivariate normal distribution with zero mean and variance-covariance matrix Σ, i.e, (ϵ_{1i}, ϵ_{2i},ϵ_{3i},μ_i) $N(O, \Sigma)$ with :

$$\Sigma = \begin{bmatrix} \sigma_\mu^2 & . & . & . \\ \sigma_{1\mu} & \sigma_1^2 & . & . \\ \sigma_{2\mu} & . & \sigma_2^2 & . \\ \sigma_{3\mu} & . & . & \sigma_3^2 \end{bmatrix}$$

where σ_μ^2 is the variance of the error term in the selection equation 4.1 σ_j^2, are the variances of the error terms in consumption function refregime j and $\sigma_{j\mu}$ represents the covariance between μ_i and ϵ_{ji}. Because y_{ji}, are not observed simultaneously for a farmer, the covariance between ϵ_{ji} are not defined (Maddala, 1983).The error structure implies that the error term μ_i is correlated with the error terms of the consumption functions ϵ_{ji}. We assume that μ and ϵ are standard bivariate normal with correlation ρ, so, the conditional distribution of μ given ϵ_j is normal with mean $\rho_j \epsilon_j$ and variance $1 - \rho_j^2$.

Instead of the two-step procedure (see Maddala, 1983), we use the Full information maximum likelihood estimation to estimate the model (FIML) (Lee and Trost, 1978) (Chiburis and Lokshin, 2007). It consists in finding the parameters β_j, γ_j, c_j, ρ_j, σ_j values that maximize the likelihood of the data. Given the parameters, the likelihood of an observation i in which the category j and y_i is observed :

$$L_{ij}^y = L\left[y_{ji}|x_i, \beta, \gamma_j, \rho_j, \sigma_j, c_j\right] \tag{B.1}$$

$$= L\left[x_i, \gamma_j, \sigma_i\right] Pr[j|y_{ji}, x_i, \beta, \gamma_j, \rho_j, \sigma_i, c_j] \tag{B.2}$$

$$= \frac{1}{\sigma_i}\phi(t_i)\left[\Phi\left(\frac{\beta X_i + \rho_j t_i - c_i}{\sqrt{1-\rho_j^2}}\right) - \Phi\left(\frac{\beta X_i + \rho_j t_i - c_{i+1}}{\sqrt{1-\rho_j^2}}\right)\right] \tag{B.3}$$

Where $t_i = (y_i - \beta_j' x_i)/\sigma_j$, ϕ is the standard normal density function, and Φ is the standard normal cumulative distribution function.

The identification of the model requires the exclusion criteria which means the introduction of identifying (or selection) variables Z_i amongs $X_i = (W_i, Z_i)$ in the first step. These identifying variables are supposed to explain the selection but not directly the productivity. Ali et al. (2014) use two sets of identifying variables: the value of non-productive household assets (consumer's durables and livestock) and, access to social networks and information of the individuals. In line with this work, we use similar indicators to define our selection variables.

Figure 2: Distribution of the value of credit per gender

C Statistic tables

Table A1: Plots' characteristics by status of credit constraint

	All			Female			Male		
	Mean High	Difference Medium - High	Difference Low - High	Mean High	Difference Medium - High	Difference Low - High	Mean High	Difference Medium - High	Difference Low - High
Management mode, type of ground, landforms									
Individual management (YES)	0.3	0.0	-0.2***	0.7	0.1***	-0.2***	0.1	0.0***	-0.1***
		(-1.4)	(-23.3)		(6.9)	(-10.6)		(-4.4)	(-9.6)
Type of crop									
Food crop	0.7	-0.0*	-0.0***	0.5	-0.0**	0.0**	0.8	-0.0*	-0.1***
		(-1.6)	(-3.0)		(-2.0)	(2.1)		(-1.6)	(-8.7)
Cash crop	0.3	0.0	-0.1***	0.5	0.0***	-0.1***	0.2	0.0	0.0
		(0.9)	(-7.1)		(2.0)	(-2.8)		(0.9)	(-0.9)
Vegetables	0.0	0.0*	0.1***	0.0	0.0	0.0**	0.0	0.0*	0.1***
		(1.8)	(16.3)		(0.1)	(2.4)		(1.6)	(15.2)
Type of land forms									
Plain	0.6	-0.1***	0.0*	0.6	0.0**	0.0	0.6	-0.1***	0.0
		(-9.4)	(-1.6)		(-2.5)	(-0.3)		(-9.3)	(-0.9)
Plateau	0.3	0.1***	0.0	0.3	0.1***	0.0	0.3	0.1***	0.0*
		(7.3)	(-0.7)		(3.0)	(0.2)		(6.5)	(-1.7)
Low-lands	0.1	0.0	0.0***	0.1	-0.0*	0.0	0.1	0.0**	0.0***
		(1.1)	(4.3)		(-1.8)	(1.0)		(2.2)	(4.8)
Slope	0.0	0.0***	-0.0	0.0	0.0**	-0.0**	-0.0**	0.0***	-0.0
		(4.8)	(-1.3)		(2.1)	(-2.5)		(4.3)	(-1.1)
Soil types									
Sandy soil	0.5	-0.1***	-0.1***	0.5	-0.0	-0.0*	0.5	-0.1***	-0.1***
		(-5.8)	(-7.8)		(-1.3)	(-1.9)		(-6.0)	(-8.1)
Clay soil	0.3	0.1***	0.0***	0.3	0.1***	0.0	0.3	0.1***	0.1***
		(8.6)	(6.1)		(3.8)	(1.1)		(7.9)	(6.9)
Lateriste soil	0.2	-0.0**	0.0*	0.2	-0.0***	0.0	0.2	0.0	0.0
		(-2.5)	(1.7)		(-3.0)	(0.7)		(-1.3)	(1.3)
Other soil	0.0	0.0	0.0**	0.0	0.0	0.0	0.0	0.0	0.0**
		(-1.1)	(2.3)		(-0.5)	(0.9)		(-0.9)	(2.3)
Inputs, use of storage technique and cultivated area									
Chemical fertilizers (YES)	0.2	0.0**	0.2***	0.1	-0.0	0.1***	0.2	0.0**	0.1***
		(2.3)	(18.8)		(-1.0)	(4.0)		(2.5)	(16.3)

Table A1 Characteristics of the plot by status of credit constraint

	Total			Female			Male		
Garbage as fertilizers (YES)	0.2	-0.1***	-0.1***	0.2	-0.1***	-0.1***	0.2	-0.0***	-0.1***
		(-7.2)	(-12.6)		(-5.4)	(-5.8)		(-5.3)	(-11.1)
Phytosanitary products (YES)	0.2	0.0***	0.3***	0.1	-0.0***	0.1***	0.2	0.0***	0.3***
		(3.3)	(30.8)		(-2.8)	(6.2)		(4.6)	(29.3)
Storage technique (YES)	0.3	0.0**	0.0**	0.3	0.0**	0.0	0.3	0.0**	0.0**
		(2.4)	(2.4)		(2.1)	(1.3)		(2.4)	(2.1)
Observations	8,786	12,403	13,584	6,600	9,409	10,846	2,186	2,994	2,738

t-stat in parentheses
* p<0.1 ** p<0.05 *** p<0.01
Source: EMC 2014, Agricultural household sample, authors calculations

Figure A1: IVregression: IV exogenous test in credit constraint impact on consumption per capita

Test			Statatistics and critical value
Underidentification test	Kleibergen-Paap rk LM statistic		73.066
Chi-sq(3) P-val =			0.0000
Weak identification test (Cragg-Donald Wald F statistic):			28.744
(Kleibergen-Paap rk Wald F statistic):			23.707
	Stock-Yogo weak ID test critical values: 5% maxima		13.91
	10% maximal IV relative	bias	9.08
	20% maximal IV relative	bias	6.46
	30% maximal IV relative	bias	5.39
	10% maximal IV	size	22.30
	15% maximal IV	size	12.83
	20% maximal IV	size	9.54
	25% maximal IV	size	7.80
NB: Critical values are for Cragg-Donald F statistic and i.i.d. errors.			
Hansen J statistic	(overidentification test of all instruments):		1.635
Chi-sq(2) P-val =			0.4416
Instrumented: Credit constraint index (cci)			

Included instruments: Age;Age square;gender=Female;Owner;Primary school;High school;Is maried;Is the partener of the household chief;Is the household chief;Type of ground: Sandy;Type of ground: Clayey;Type of ground: Lateritic / red;Farm location= in the village;Ground use secure: Official document;Ground use secure: Lease or loan;Ground use secure: Landowner;Regionalheterogeneity;Household chief age;Dependacy;Number of adult females;Number of adult males

Excluded instruments: Is a member of an association;Is a member of an association decision-making staff;Proportion of persons member of an association in the district;

Figure A2: IVregression: IV exogenous test in credit constraint impact on all agriculture products

Test			Statatistics and critical value
Underidentification test	Kleibergen-Paap rk LM statistic		40.779
Chi-sq(3) P-val =			0.0000
Weak identification test (Cragg-Donald Wald F statistic):			60.988
(Kleibergen-Paap rk Wald F statistic):			14.367
	Stock-Yogo weak ID test critical values: 5% maximal IV relative		13.91
	10% maximal IV relative	bias	9.08
	20% maximal IV relative	bias	6.46
	30% maximal IV relative	bias	5.39
	10% maximal IV	size	22.30
	15% maximal IV	size	12.83
	20% maximal IV	size	9.54
	25% maximal IV	size	7.80
NB: Critical values are for Cragg-Donald F statistic and i.i.d. errors.			
Hansen J statistic	(overidentification test of all instruments):		1.408
Chi-sq(2) P-val =			0.4947
	Instrumented: Credit constraint index (cci)		

Included instruments: Gender;owner; education_primary; education_secondary and higher; Log of age; log of age square; matrimonial situation; Is head of household;is the partner of head of household; Type of ground: Sandy;Type of ground: Clayey;Type of ground: Lateritic / red;Farm location= in the village; Ground use secure: Official document;Ground use secure: Lease or loan;Ground use secure: Landowner;Ground is Plateau;Ground is bas-fond;Ground is slope;Log of age of the head of household;Number of female adult;Number of male adult; dependacy;current value of valuables;regional price index; region dummy

Excluded instruments: Is a member of an association;Is a member of an association decision-making staff;Proportion of persons member of an association in the district;

Figure A3: IVregression: IV exogenous test in credit constraint impact on rent and market agriculture products

Test			Statatistics and critical value
Underidentification test (Kleibergen-Paap rk LM statistic):			40.296
Chi-sq(3) P-val =			0.0000
Weak identification test (Cragg-Donald Wald F statistic):			26.708
(Kleibergen-Paap rk Wald F statistic):			14.839
	Stock-Yogo weak ID test critical values: 5% maximal IV relative bias		13.91
	10% maximal IV relative	bias	9.08
	20% maximal IV relative	bias	6.46
	30% maximal IV relative	bias	5.39
	10% maximal IV	size	22.30
	15% maximal IV	size	12.83
	20% maximal IV	size	9.54
	25% maximal IV	size	7.80
NB: Critical values are for Cragg-Donald F statistic and i.i.d. errors.			
Hansen J statistic (overidentification test of all instruments):			2.319
Chi-sq(2) P-val =			0.3136
Instrumented:	Credit constraint index (cci)		

Included instruments: Gender;owner; education_primary; education_secondary and higher; Log of age; log of age square; matrimonial situation; Is head of household;is the partner of head of household; Type of ground: Sandy;Type of ground: Clayey;Type of ground: Lateritic / red;Farm location= in the village; Ground use secure: Official document;Ground use secure: Lease or loan;Ground use secure: Landowner;Ground is Plateau;Ground is bas-fond;Ground is slope;Log of age of the head of household;Number of female adult;Number of male adult; dependacy;current value of valuables;regional price index; region dummy

Excluded instruments: Is a member of an association;Is a member of an association decision-making staff;Proportion of persons member of an association in the district;

Table A2: Estimaton of credit constraint impact on yields per ha

Variables	All Farmers				Men Farmers				Women Farmers			
	(1) HCC	(2) MCC	(3) LCC	(4) CCI	(5) HCC	(6) MCC	(7) LCC	(8) CCI	(9) HCC	(10) MCC	(11) LCC	(12) CCI
Farmer characteristics												
Age	-0.14	-0.08	2.16***	0.23**	-0.11	-0.29	3.33***	0.11	-0.19	-0.22	1.43	0.31*
	(0.19)	(0.30)	(0.80)	(0.12)	(0.48)	(0.90)	(0.32)	(0.35)	(0.20)	(0.54)	(1.36)	(0.17)
Female	-0.15	-0.20*	-0.14	-0.24***								
	(0.09)	(0.11)	(0.41)	(0.07)								
Owner	-0.13	0.13	0.34*	0.04	-0.15	0.25*	0.32	-0.01	-0.11	-0.19	1.01**	0.11
	(0.10)	(0.13)	(0.20)	(0.08)	(0.10)	(0.14)	(0.21)	(0.10)	(0.10)	(0.19)	(0.48)	(0.11)
Is the partner of the household chief	0.23	0.03	-1.40**	-0.02	0.55	0.25		-0.44	0.16	-0.55	-0.97	0.07
	(0.14)	(0.27)	(0.55)	(0.22)	(0.35)	(0.45)		(0.53)	(0.16)	(0.48)	(0.80)	(0.18)
Is the household chief	0.11	-0.20	-1.57**	0.55***	0.16	0.27	-2.59***	0.56	0.05	-0.41	-3.35**	0.63***
	(0.20)	(0.29)	(0.67)	(0.21)	(0.51)	(0.69)	(0.19)	(0.40)	(0.22)	(0.62)	(1.56)	(0.20)
Is maried	-0.15	0.01	0.20	0.29**	-0.22	-0.04	0.21	0.39***	-0.19	0.10		0.20
	(0.12)	(0.12)	(0.23)	(0.12)	(0.16)	(0.18)	(0.25)	(0.15)	(0.15)	(0.30)		(0.14)
Ground characteristics												
Ground use secure: Official document	-0.00	0.03	0.05	0.08**	-0.01	0.02	0.02	0.08**	-0.07	0.10		0.18
	(0.03)	(0.04)	(0.09)	(0.03)	(0.03)	(0.04)	(0.09)	(0.03)	(0.13)	(0.13)		(0.12)
Ground use secure: Lease or loan	0.01	-0.01	0.08**	0.04**	-0.01	0.01	0.06	0.03	0.04	-0.05	0.95*	0.05
	(0.03)	(0.04)	(0.04)	(0.02)	(0.04)	(0.04)	(0.04)	(0.02)	(0.07)	(0.15)	(0.58)	(0.05)
Ground use secure: Landowner	0.04**	0.03**	-0.02	-0.02	0.03*	0.02	-0.03	-0.01	0.07*	0.14*	0.64**	0.01
	(0.02)	(0.02)	(0.03)	(0.02)	(0.02)	(0.02)	(0.03)	(0.02)	(0.04)	(0.07)	(0.30)	(0.05)
Regional heterogeneity	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes				
Household chief age	0.18	-0.09	-1.92**	-0.42***	0.17	0.13	-3.08***	-0.35	0.18	-0.29	-0.92	-0.40**
	(0.18)	(0.30)	(0.81)	(0.15)	(0.44)	(0.90)	(0.33)	(0.38)	(0.18)	(0.43)	(1.52)	(0.18)
Log unit price	0.01	0.03	-0.08	0.06***	0.02	0.01	-0.09	0.06***	0.04	0.18**	0.16	0.05
	(0.03)	(0.04)	(0.06)	(0.02)	(0.04)	(0.03)	(0.06)	(0.02)	(0.03)	(0.07)	(0.18)	(0.03)
Identification variables												
is a member of an association				0.19***				0.15***				0.31***
				(0.06)				(0.06)				(0.11)
Is a member of an association decision-making staff				0.25***				0.30***				0.04
				(0.07)				(0.07)				(0.22)

Table A2 continued from previous page

Variables	All Farmers				Men Farmers				Women Farmers			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
	HCC	MCC	LCC	CCI	HCC	MCC	LCC	CCI	HCC	MCC	LCC	CCI
Proportion of persons member of an association in the district				2.72**				1.72				1.19
				(1.32)				(1.53)				(1.37)
Constant	5.86***	7.68***	7.49***		5.68***	7.33***	8.70***		5.42***	6.68***	4.61	
	(0.46)	(0.69)	(1.31)		(0.70)	(0.87)	(1.15)		(0.60)	(2.54)	(3.21)	
cut_4_1	0.99**				0.77	(0.58)			1.85***			
	(0.45)					(0.56)			(0.68)			
cut_4_2	2.32***				2.16***	(0.08)			2.91***			
	(0.43)					(0.09)			(0.68)			
lnsig_1	0.08				0.13	(0.12)			0.05			
	(0.07)				-0.03	(0.22)			(0.05)			
lnsig_2	-0.02				-0.36***	(0.14)			-0.11			
	(0.08)				-0.80***	(0.26)			(0.10)			
lnsig_3	-0.34***				-0.41***				-0.19			
	(0.10)				0.25				(0.27)			
atanhrho_14	-0.66***								-0.67***			
	(0.24)								(0.19)			
atanhrho_24	-0.40***								0.02			
	(0.14)								(0.68)			
atanhrho_34	0.30								-0.99**			
	(0.27)								(0.50)			
Observations	3,422	3,422	3,422	3,422	2,223	2,223	2,223	2,223	1,199	1,199	1,199	1,199

Table A3: Switching regression model: Consumption per capita by gender

Variables	Men				Women			
	(1) LCC	(2) MCC	(3) HCC	(4) CCI	(5) LCC	(6) MCC	(7) HCC	(8) CCI
log of age	0.00	-0.06	-0.14***	-0.08	0.08	-0.01	-0.04	-0.02
	(0.08)	(0.05)	(0.03)	(0.09)	(0.13)	(0.05)	(0.04)	(0.12)
Primary school (=1)	0.14***	0.09*	0.12***	0.09	0.46**	0.07	0.26***	0.16
	(0.05)	(0.05)	(0.03)	(0.06)	(0.20)	(0.09)	(0.06)	(0.14)
High School (=1)	0.21***	0.27**	0.20***	-0.04	0.07	0.25	0.23	-0.01
	(0.07)	(0.11)	(0.06)	(0.10)	(0.22)	(0.22)	(0.14)	(0.30)
Owner of farm (=1)	-0.05	-0.05	0.04	0.05	-0.04	-0.01	0.12*	0.14
	(0.04)	(0.04)	(0.05)	(0.09)	(0.11)	(0.09)	(0.07)	(0.14)
Has desabbility (=1)	0.03	0.06	-0.04	0.13	-0.14	-0.08	-0.05	-0.21*
	(0.07)	(0.10)	(0.04)	(0.10)	(0.13)	(0.09)	(0.06)	(0.11)
Type of ground: Sandy (=1)	0.01	-0.00	0.03	-0.06	0.02	-0.05*	0.03	-0.11***
	(0.01)	(0.03)	(0.02)	(0.04)	(0.04)	(0.03)	(0.03)	(0.04)
Type of ground: Clay (=1)	0.01	0.00	0.03	-0.12***	0.12	0.02	0.02	-0.18***
	(0.02)	(0.07)	(0.02)	(0.04)	(0.08)	(0.03)	(0.03)	(0.05)
Type of ground: Lateritic (=1)	0.01	-0.00	0.01	-0.07	0.03	-0.03	-0.02	-0.13**
	(0.02)	(0.05)	(0.02)	(0.04)	(0.05)	(0.05)	(0.02)	(0.05)
Farm location : In the village (=1)	0.05*	0.00	-0.04*	-0.01	0.08	0.04	0.00	-0.05
	(0.03)	(0.03)	(0.02)	(0.05)	(0.08)	(0.05)	(0.04)	(0.09)
Type of secure of ground: Official document (=1)	-0.05	0.04	0.04	-0.11*	-0.04	-0.01	-0.08	-0.12
	(0.03)	(0.05)	(0.05)	(0.06)	(0.10)	(0.06)	(0.10)	(0.15)
Type of secure of ground: Lease or loan (=1)	-0.04**	-0.00	-0.01	-0.02	-0.09***	-0.04	-0.05	-0.02
	(0.01)	(0.02)	(0.02)	(0.04)	(0.03)	(0.04)	(0.03)	(0.06)
Type of secure of ground: Landowner (=1)	-0.03*	0.01	-0.03***	-0.01	-0.10***	0.01	-0.09***	-0.01
	(0.02)	(0.01)	(0.01)	(0.05)	(0.03)	(0.03)	(0.03)	(0.07)
Agro ecology heterogeneity : yes (=1)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Dependacy	-0.05***	-0.04**	-0.06***	-0.04***	-0.06**	-0.04***	-0.07***	-0.04***
	(0.01)	(0.02)	(0.01)	(0.01)	(0.02)	(0.01)	(0.01)	(0.01)
Number of female in the household	0.02	0.01	0.02	0.06***	0.02	0.03	0.05***	0.04
	(0.02)	(0.03)	(0.01)	(0.02)	(0.04)	(0.02)	(0.02)	(0.03)
logarithm of the age of the head of household	-0.08	-0.03	0.04	0.23***	-0.13	0.04	0.00	0.10
	(0.06)	(0.10)	(0.03)	(0.05)	(0.09)	(0.05)	(0.03)	(0.07)
Proportion of persons member of an association in the district				-0.53				0.69
				(0.65)				(0.60)
Is a member of an association decision making staff (=1)				-0.30***				-0.27*
				(0.11)				(0.14)
Is female farmer (=1)	0.00	-0.05	0.02	0.18***				
	(0.06)	(0.08)	(0.03)	(0.06)				
Constant	13.21***	12.96***	12.67***		13.13***	12.14***	12.18***	
	(0.14)	(0.58)	(0.30)		(0.80)	(0.35)	(0.20)	
cutoff(1)				***0.86	-0.38			
				(0.19)	(0.40)			

Table A3 continued from previous page

VARIABLES	Men				Women			
	(1) LCC	(2) MCC	(3) HCC	(4) CCI	(5) LCC	(6) MCC	(7) HCC	(8) CCI
cutoff(2)				1.51***	0.44			
				(0.20)	(0.38)			
ln σ_1	-0.86***				-0.84***			
	(0.03)				(0.10)			
ln σ_2		-0.91***				-0.81***		
		(0.02)				(0.16)		
ln σ_3			-0.89***				-0.74***	
			(0.04)				(0.07)	
atanh ρ_{14}	0.02				0.11			
	(0.39)				(1.06)			
atanh ρ_{24}		0.00				0.68**		
		(1.20)				(0.30)		
atanh ρ_{34}			-0.00				1.00***	
			(0.44)				(0.18)	
Observations	6,627	6,627	6,627	6,627	2,054	2,054	2,054	2,054

Note: * p<0.1 ** p<0.05 *** p<0.01.
LCC Low credit constraint, MCC Medium credit constraint, HCC High credit constraint

Table A4: Switching regression model: Plot yields by gender

Variables	Men				Women			
	(1) LCC	(2) MCC	(3) HCC	(4) CCI	(5) LCC	(6) MCC	(7) HCC	(8) CCI
log of age	0.00	-0.06	-0.14***	-0.08	0.08	-0.01	-0.04	-0.02
	(0.08)	(0.05)	(0.03)	(0.09)	(0.13)	(0.05)	(0.04)	(0.12)
Primary school	0.14***	0.09*	0.12***	0.09	0.46**	0.07	0.26***	0.16
	(0.05)	(0.05)	(0.03)	(0.06)	(0.20)	(0.09)	(0.06)	(0.14)
High School	0.21***	0.27**	0.20***	-0.04	0.07	0.25	0.23	-0.01
	(0.07)	(0.11)	(0.06)	(0.10)	(0.22)	(0.22)	(0.14)	(0.30)
Owner of farm	-0.05	-0.05	0.04	0.05	-0.04	-0.01	0.12*	0.14
	(0.04)	(0.04)	(0.05)	(0.09)	(0.11)	(0.09)	(0.07)	(0.14)
Has desabbility	0.03	0.06	-0.04	0.13	-0.14	-0.08	-0.05	-0.21*
	(0.07)	(0.10)	(0.04)	(0.10)	(0.13)	(0.09)	(0.06)	(0.11)
Type of ground: Sandy	0.01	-0.00	0.03	-0.06	0.02	-0.05*	0.03	-0.11***
	(0.01)	(0.03)	(0.02)	(0.04)	(0.04)	(0.03)	(0.03)	(0.04)
Type of ground: Clay	0.01	0.00	0.03	-0.12***	0.12	0.02	0.02	-0.18***
	(0.02)	(0.07)	(0.02)	(0.04)	(0.08)	(0.03)	(0.03)	(0.05)
Type of ground: Lateritic	0.01	-0.00	0.01	-0.07	0.03	-0.03	-0.02	-0.13**
	(0.02)	(0.05)	(0.02)	(0.04)	(0.05)	(0.05)	(0.02)	(0.05)
Farme location : In the village	0.05*	0.00	-0.04*	-0.01	0.08	0.04	0.00	-0.05
	(0.03)	(0.03)	(0.02)	(0.05)	(0.08)	(0.05)	(0.04)	(0.09)
Type of secure of ground: Official document	-0.05	0.04	0.04	-0.11*	-0.04	-0.01	-0.08	-0.12
	(0.03)	(0.05)	(0.05)	(0.06)	(0.10)	(0.06)	(0.10)	(0.15)
Type of secure of ground: Lease or loan	-0.04**	-0.00	-0.01	-0.02	-0.09***	-0.04	-0.05	-0.02
	(0.01)	(0.02)	(0.02)	(0.04)	(0.03)	(0.04)	(0.03)	(0.06)
Type of secure of ground: Landowner	-0.03*	0.01	-0.03***	-0.01	-0.10***	0.01	-0.09***	-0.01
	(0.02)	(0.01)	(0.01)	(0.05)	(0.03)	(0.03)	(0.03)	(0.07)
Agro ecology heterogeniety : yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Dependacy ratio	-0.05***	-0.04**	-0.06***	-0.04***	-0.06**	-0.04***	-0.07***	-0.04***
	(0.01)	(0.02)	(0.01)	(0.01)	(0.02)	(0.01)	(0.01)	(0.01)
Number of female in the household	0.02	0.01	0.02	0.06***	0.02	0.03	0.05***	0.04
	(0.02)	(0.03)	(0.01)	(0.02)	(0.04)	(0.02)	(0.02)	(0.03)
logarithm of the age of the head of household	-0.08	-0.03	0.04	0.23***	-0.13	0.04	0.00	0.10
	(0.06)	(0.10)	(0.03)	(0.05)	(0.09)	(0.05)	(0.03)	(0.07)
Proportion of persons member of an association in the district				-0.53				0.69
				(0.65)				(0.60)
Is a member of an association decision making staff				-0.30***				-0.27*
				(0.11)				(0.14)
Is female farmer	0.00	-0.05	0.02	0.18***				
	(0.06)	(0.08)	(0.03)	(0.06)				
Constant	13.21***	12.96***	12.67***		13.13***	12.14***	12.18***	
	(0.14)	(0.58)	(0.30)		(0.80)	(0.35)	(0.20)	
cutoff(1)				0.86***				-0.38
				(0.19)				(0.40)
cutoff(2)				1.51***				0.44
				(0.20)				(0.38)
ln σ_1	-0.86***				-0.84***			
	(0.03)				(0.10)			
ln σ_2		-0.91***				-0.81***		
		(0.02)				(0.16)		
ln σ_3				-0.89***			-0.74***	
				(0.04)			(0.07)	
atanh ρ_{14}	0.02				0.11			
	(0.39)				(1.06)			
atanh ρ_{24}		0.00				0.68**		
		(1.20)				(0.30)		
atanh ρ_{34}			-0.00				0.99 ***	
			(0.44)				(0.18)	
Observations	6,627	6,627	6,627	6,627	2,054	2,054	2,054	2,054

Note: * p<0.1 ** p<0.05 *** p<0.01.
LCC Low credit constraint, MCC Medium credit constraint, HCC High credit constraint.

Table A5: Estimaton of credit constraint impact on yields per ha normalized for rente and market crops

Variables	Men				Women			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	LCC	MCC	HCC	CCI	LCC	MCC	HCC	CCI
Farmer characteristics								
Age square	-0.11	0.06	-0.10	-0.04	0.04	0.04	0.02	0.15
	(0.14)	(0.12)	(0.07)	(0.07)	(0.21)	(0.23)	(0.08)	(0.12)
Female	-0.14*	-0.13	0.01	0.07	-0.33	-0.29	-0.21	0.21
	(0.08)	(0.09)	(0.07)	(0.08)	(0.49)	(0.44)	(0.13)	(0.24)
Owner	0.18	-0.26*	-0.05	0.18	-0.03	-0.46	0.27	0.09
	(0.17)	(0.14)	(0.12)	(0.13)	(0.55)	(0.83)	(0.31)	(0.43)
Primary school	-0.14	3.19	1.48*	-6.59***	1.23	0.70	1.80	-6.28***
	(2.64)	(2.41)	(0.78)	(1.63)	(4.25)	(0.49)	(1.65)	(2.43)
High school	-0.00	-0.46	-0.19	0.93***	-0.15	-0.07	-0.21	0.89***
	(0.37)	(0.33)	(0.12)	(0.22)	(0.61)	(0.10)	(0.23)	(0.34)
Is maried	-0.31**	0.13	-0.15	-0.10	-0.24	0.10	0.37***	0.40***
	(0.14)	(0.11)	(0.15)	(0.10)	(0.21)	(0.30)	(0.09)	(0.14)
Is the partner of the household chief	0.20	0.23	-0.06	-0.21	1.23	0.07	0.20	-0.42***
	(0.98)	(0.25)	(0.20)	(0.27)	(0.93)	(0.64)	(0.15)	(0.16)
Is the household chief			-0.12	4.40***	2.23***	0.22	0.14	-0.27*
			(0.26)	(0.25)	(0.85)	(0.37)	(0.13)	(0.14)
Ground characteristics								
Type of ground: Sandy	0.17*	-0.05	-0.10*	0.01	-0.24	-0.07	0.02	0.14
	(0.09)	(0.09)	(0.06)	(0.06)	(0.20)	(0.28)	(0.09)	(0.13)
Type of ground: Clayey	0.21**	-0.02	0.07	-0.22***	-0.25	-0.02	0.02	0.03
	(0.09)	(0.12)	(0.06)	(0.06)	(0.18)	(0.20)	(0.12)	(0.13)
Farm location= in the village	-0.01	0.12*	0.16***	-0.04				
	(0.07)	(0.06)	(0.04)	(0.04)				
Ground use secure: Official document	-0.02	-0.12	-0.00	-0.14	0.09	0.07	0.15*	-0.08
	(0.21)	(0.18)	(0.11)	(0.16)	(0.16)	(0.12)	(0.08)	(0.08)
Ground use secure: Lease or loan	-0.12	-0.03	0.01	-0.10	-0.20	-0.18	-0.16	0.08
	(0.14)	(0.13)	(0.08)	(0.08)	(0.42)	(0.30)	(0.14)	(0.37)
Ground use secure: Landowner	-0.02	0.03	0.11**	-0.02	0.33	0.01	-0.07	0.33**
	(0.10)	(0.08)	(0.05)	(0.06)	(0.24)	(0.39)	(0.10)	(0.14)
Ground is Plateau	-0.07	0.00	0.18***	0.03	-0.02	-0.05	0.09	0.11
	(0.08)	(0.08)	(0.06)	(0.05)	(0.22)	(0.23)	(0.10)	(0.12)
Ground is bas-fond	0.07	-0.07	0.03	0.10	0.24	0.01	-0.01	-0.17
	(0.12)	(0.09)	(0.07)	(0.07)	(0.19)	(0.22)	(0.09)	(0.11)

Ground is slope	0.13	-0.13	-0.07	0.08	-0.09	0.41*	0.22	0.02
	(0.21)	(0.12)	(0.10)	(0.11)	(0.23)	(0.22)	(0.17)	(0.16)
Household characteristics								
Household chief age	0.29	0.01	-0.02	0.09	-0.51	0.10	-0.21	0.18
	(1.00)	(0.23)	(0.24)	(0.33)	(1.68)	(0.29)	(0.15)	(0.18)
Number of adult females	0.01	-0.03	0.00	0.03	0.09	-0.01	-0.07*	-0.05
	(0.04)	(0.03)	(0.02)	(0.02)	(0.13)	(0.06)	(0.04)	(0.04)
Number of adult males	-0.01	0.03	0.01	-0.02	0.00	0.05	0.06	0.03
	(0.03)	(0.03)	(0.02)	(0.02)	(0.22)	(0.07)	(0.04)	(0.05)
Dependacy	-0.00	0.01	0.01	-0.03***	0.06	0.00	0.04***	-0.04**
	(0.02)	(0.01)	(0.01)	(0.01)	(0.06)	(0.07)	(0.02)	(0.02)
Current value of valuables	0.00	0.00	0.00	-0.00	-0.00	-0.00	0.00	0.00
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Regional price index	51,065.54*	44,666.15	30,119.73***	-135,216.51***	2,840.17	106,359.41	65,631.86**	-18,836.14
	(29,416.20)	(38,871.01)	(11,633.84)	(12,164.19)	(29,814.02)	(71,362.96)	(33,137.70)	(31,332.60)
Regionalheterogeneity	Yes	Yes	Yes	Yes	Yes	Yes	Yes	yes
Identification variables								
is a member of an association				-0.20**				-0.49***
				(0.09)				(0.15)
Is a member of an association decision-making staff				-0.29***				-0.23
				(0.09)				(0.27)
Proportion of persons member of an association in the district				-2.34***	0.46	-0.33	0.03	-1.33
				(0.48)	(0.58)	(1.21)	(0.18)	(0.34)
Constant	0.50	-5.30	-1.74		-1.15	-1.45	-2.60	
	(5.47)	(4.62)	(1.86)		(8.49)	(0.00)	(3.00)	
cut_4_1	-13.77***				-12.12***			
	(3.12)				(4.36)			
cut_4_2	-12.96***				-11.23**			
	(3.12)				(4.37)			
lnsig_1	0.23***				-0.04			
	(0.05)				(0.09)			
lnsig_2	0.17***				0.10			
	(0.05)				(0.08)			
lnsig_3	0.20***				0.25***			
	(0.08)				(0.08)			
atanhrho_14	-0.01				0.01			
	(0.22)				(0.00)			
atanhrho_24	-0.01				0.02			
	(0.25)				(1.24)			

atanhrho_34	0.01				-0.01			
	(0.00)				(0.10)			
Observations	11,497	11,497	11,497	11,497	2,428	2,428	2,428	2,428

note: Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table A6: Credit constraint treatment effects on plot yields by gender

Farmer	Observed (Sample)	Counterfactual	ATET	ATET robuste	N	ATU	ATU robuste	N
	LCC	MCC	0,072***	-0,219***	3645	0,0613***	0,0938***	2604
Man	LCC	HCC	0,0524***	0,0536**	3645	0,05139***	0,1716***	6443
	MCC	HCC	-0,054**	-0,066***	2604	-0,05740***	-0,0843***	6443
	LCC	MCC	-0,2089***	-0,209***	495	0,028***	0,029	515
Woman	LCC	HCC	-0,1435***	-0,1456***	495	-0,1304***	-0,1288***	1626
	MCC	HCC	-0,088	-0,08844377	515	0,0335	0,035	1626