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Causes and Implications of Credit Rationing in Rural Ethiopia

The Importance of Spatial Variation

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Abstract

This paper uses Ethiopian data to explore credit rationing in semi-formal credit markets and its effects on farmers' resource allocation and crop productivity. Credit rationing—both voluntarily and involuntarily—is found to be widespread in the sampled rural villages, largely because of risk-related factors. Political and social networks emerge as key determinants of access to credit among smallholder, peasant farmers. Significant regional variation emerges as well. In high-potential, surplus producing areas where credit is largely used for agricultural production, eliminating credit constraints is estimated to increase productivity by roughly 11 percentage points. By contrast, in low-productivity, drought prone areas where loans were rarely used to acquire inputs for crop production, the authors find no relationship between credit rationing and agricultural productivity. To be effective, efforts to improve agricultural productivity not only need to increase credit supply, but also explore the reasons for credit rationing and the availability of productive opportunities.

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Causes and Implications of Credit Rationing in Rural Ethiopia: The Importance of Spatial Variation

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1. Introduction

Intensification of peasant agriculture, by increasing the use of modern inputs such as fertilizer and high yielding varieties, through centralized extension services that focuses on technological packages and government-guaranteed credits has been a key policy emphasized by Ethiopia's overall development strategy of agricultural-led growth (Dercon and Christiaensen 2011; World Bank 2007). In a setting where high exposure to risk and meager surpluses from subsistence agriculture limit opportunities for self-insurance and savings, provision of credit is often seen as a key element to increase productivity through more intensive use of fertilizer and seed and to facilitate consumption smoothing. However, the potential impact of such a strategy and the extent to which it should be complemented with other efforts to improve access to technology have not been subject to rigorous analysis.

To fill the gap, this study investigates the productivity impact of being credit constrained in the semi-formal sector of two regions in Ethiopia, one of them, Gojam, surplus producing and another one, Wollo, with more limited agricultural potential. We use a survey-based direct elicitation approach to identify credit constrained and unconstrained households. As disequilibrium is likely in credit markets, an endogenous switching regression model is used to explore the returns on productive endowments for constrained and unconstrained households. Findings suggest that political connections matter in determining access to semi-formal sector loans. Being credit constrained affects productivity in more productive villages where loans were used to buy agricultural inputs, with an estimated productivity loss of 11.4 percentage points due to being credit constrained. While this supports the notion of credit access being important for productivity of land use in the villages with potential, we find no evidence of an appreciable effect of being credit constrained in less productive areas where loans were largely used for purposes of non-farm activities and consumption smoothing, implying that allocation of credit might be governed by non-economic criteria. Before putting in place efforts to improve credit access, careful analysis of reasons for credit rationing and the impact of alternative policies will be appropriate.

The paper is organized as follows. Section 2 provides the conceptual framework discussing the potential impacts of credit market imperfections. It also discusses ways to obtain information on households' credit constrained status and, on this basis presents the direct elicitation approach and elaborates the estimation strategy used. Section three introduces the data and presents descriptive statistics both on credit access and use, the incidence and reasons for credit rationing, and the characteristics of credit constrained vs. unconstrained households in the two regions. Section four provides empirical results on determinants of credit access as well as, using the endogenous switching model, the impact of credit access on productivity of resource use. Section five concludes with a number of policy implications.

2. Conceptual and econometric framework

Moral hazard and informational imperfections imply that equilibrium credit rationing will be observed. We first use this framework to identify determinants of credit rationing on the supply- and the demand-side and discuss how different types of credit rationing can be identified empirically through survey-based elicitation. This allows us to identify ways of estimating a switching regression to estimate determinants of being credit constrained and to use these estimates to quantify the impacts on agricultural productivity.

2.1 The impact of credit market imperfections

With perfect and complete markets, farm households' production and consumption decisions are separable so that initial resource endowments or perceived risks will not affect decisions on input use. This implies that, for example, productivity will be independent of initial endowments of key factors such as land, family labor and oxen. In an environment characterized by market imperfections common in developing countries, this will no longer be the case and output per unit of land will be affected by the level of liquidity as well as resource endowments. In this case, limited endowments with key resources, rather than inefficiency, may prevent producers from using levels of variable inputs to allow them achieving optimum levels of productivity.

The way in which production is organized and resources are used in smallholder farms therefore will, *inter alia*, depend on the degree of credit market functioning (Conning and Udry 2007). The literature on rural credit markets in developing countries has highlighted that the lack of access to credit, either in the form of formal and semi-formal loans, can be a key impediment to higher levels of productivity (e.g., Carter 1988; Eswaran and Kotwal ; Kochar 1997; Stiglitz and Weiss). This can affect their household welfare in a number of ways, e.g., by preventing farmers from undertaking profitable investment, by biasing their portfolio of activities to those with low-risk but also low returns, or by holding inefficiently high levels of stocks to guard against risk. Recognition of the widespread nature and possibly far-reaching impacts of credit rationing has given rise to efforts to improve credit access.

Marshaling empirical evidence to document the credit regime of a household and where possible quantify the effect of credit constraints has been difficult, particularly in developing countries. Early empirical studies on the impact of credit rationing focused on restrictions on potential borrowers' credit access arising from supply side factors such as those relating to restrictions on interest rates charged (McKinnon 1973; Shaw 1973). This led to recognition of the fact that informational asymmetries and enforcement problems make it impossible for lenders to increase interest rates so as to clear excess demand for

loanable funds (Bell 1988; Stiglitz and Weiss).[1] As a consequence, equilibrium credit rationing and use of collateral to limit moral hazard by borrowers may play a role. In such a framework, borrowers' inability to meet lenders' collateral requirements and the presence of binding credit constraints could reduce productivity while liquidity and other resource endowments (such as family labor and oxen) would have non-negative effects on crop output per unit of land (Feder *et al.* 1990; Guirkinger and Boucher 2008). This, in turn, would imply lower levels of yields, income, and household welfare than in an unconstrained situation.

Determinants of credit rationing and implications of capital market imperfections on levels of investment in general have been explored in a large literature (Drakos and Giannakopoulos 2011; Hubbard 1998). Given the importance of being able to access working capital for inputs in agriculture, a large number of studies aimed to measure credit rationing empirically (Petrick 2005) and subsequently explore its impact on agricultural resource allocation, crop productivity and land related investment (e.g., Diagne and Zeller 2001; Feder *et al.* 1990; Foltz 2004; Guirkinger and Boucher 2008). These studies derive testable relationships between credit constraints and potential outcome variables using the framework of the standard agricultural household model that combines both consumption and production decisions of farm households (de Janvry *et al.* 1991; Singh *et al.* 1986).

2.2 Conceptualizing and eliciting different types of credit rationing

Many studies of credit rationing have focused primarily on supply side restrictions that affect potential borrowers' credit access in what is referred to as *quantity rationing*. Reasons include policy-induced limits on interest rates and borrowers' inability to meet the collateral requirement of lenders. A second type, t*ransaction cost rationing,* arises as a result of the cost of obtaining credit in terms of preparing a loan application, evaluating collateral and project viability, and monitoring credit use and repayment. As associated costs are largely independent from the loan amount, transaction cost rationing is likely to be particularly severe for small loans which are often catered for by informal credit markets that rely on lower-cost mechanisms for enforcement. Finally, borrowers may be *risk rationed*, implying that they are unwilling to access credit even if it were available to them because they fear the risk of being indebted and possibly losing the assets pledged as collateral (Barham *et al.* 1996; Boucher *et al.* 2008; Boucher *et al.* 2009; Carter 1988; Guirkinger and Boucher 2008). Unlike quantity rationed households, households who are either transaction cost or risk rationed forgo credit market participation voluntarily even though their projects would be feasible in competitive markets for loans. In this study, we follow others (Boucher

[1] In the face of imperfect information, lenders might not resort to increasing interest rates as an instrument to equate the demand for and supply of loanable funds because doing so would lead to an increase in the riskiness of the pool loans by either the adverse selection or the incentive effects (for the details see (Stiglitz and Weiss 1981)).

et al. 2009; Guirkinger and Boucher 2008) and consider all quantity, transaction cost and risk rationed households as being credit constrained.

As "excess demand", either through voluntarily or involuntarily rationing, cannot be directly observed, a challenge for the empirical literature has been to identify households who are constrained in credit markets. Two distinct approaches, indirect and survey based (direct elicitation) approaches, can be distinguished. First, the indirect approach relies on the life-cycle/permanent income hypothesis under which, without borrowing constraints, consumption is a function of permanent income only, and independent of any transitory components. As it is not used here, and an excellent review of its merits compared to direct elicitation is provided elsewhere (Diagne *et al.* 2000), we do not discuss it in detail.

Second, the direct elicitation approach exploits a series of questions on households' credit market participation, including their borrowing needs, experience, and overall perceptions (Barham *et al.* 1996; Boucher *et al.* 2009; Feder *et al.* 1990; Jappelli 1990). A first step is to distinguish applicants from non-applicants by directly asking them whether they applied for loans in the reference period. Non-applicants are then asked to specify why they did not apply. The answer to this question is used to identify credit constrained and unconstrained households. Those who indicated they were not interested in additional funds because they have sufficient own resources are categorized as being unconstrained while the rest will be categorized as quantity, transaction cost, or risk rationed, depending on their responses.

Depending on the outcome of their loan request, follow-up perception questions on whether they wanted to borrow more at the terms on which they received the current loan can then be used to further classify applications. Those who received the amount requested and did not want to borrow more are classified as unconstrained. On the other hand, partially or fully rejected applicants are considered quantity rationed and those who expressed interest in additional funds at the terms under which they received their loan are categorized as quantity, transaction cost, or risk rationed depending on the reasons provided for not applying for more. This study closely follows this approach, considering all quantity, transaction cost and risk rationed households as being credit constrained. Specific questions asked and possible responses used to group households based on their credit market participation status are discussed in the data section.

2.3 Estimation strategy

To test the relationship between credit constraints and agricultural productivity, we focus on identifying determinants and impacts of credit constraints in the semi-formal sector, the most important source of credit in rural Ethiopia. We do so by estimating a switching regression model of the form

$$d_i^* = \delta' X_i + \theta' W_i + u_i \qquad \textbf{(1)}$$

$$d_i = \begin{cases} 0 \; if \;\; d_i^* > 0 \\ 1 \; if \;\; d_i^* \leq 0 \end{cases} \tag{2}$$

$$y_i = \begin{cases} y_{0i} = \beta_0^{'} X_{0i} + \gamma_0^{'} Z_{0i} + \varepsilon_{0i} \quad \text{if } d_i = 0 \\ y_{1i} = \beta_1^{'} X_{1i} + \gamma_1^{'} Z_{1i} + \varepsilon_{1i} \quad \text{if } d_i = 1 \end{cases} \tag{3}$$

where d_i*, which loosely corresponds to the (unobservable) "excess demand" function for credit, is a latent variable denoting the probability of household *i* being credit unconstrained in the semi-formal sector. We represent it by the indicator variable d_i defined based on responses from survey questions as discussed above to identify households as either (quantity-, risk- or transaction cost-) constrained or unconstrained in credit markets. This indicator variable takes the value of one if the household is unconstrained and of zero if it is constrained (d_i* > 0), i.e., demand for credit exceeds available supply, other conditions being held constant.

The dependent variable is the value of crop output per hectare, y_i. Depending on the credit regime under which the household operates, we observe either the constrained or the unconstrained productivity level y_{0i}, or y_{1i}. On the right hand side, X_i is a vector of household resource endowments such as own land, family labor, and oxen, family composition, and income from non-farm activities, that can explain productivity and credit availability. Z_i includes a measure of credit-based liquidity (credit received during the past 12 months from all sources), farm characteristics such as soil quality, slope, access to irrigation and length of possession that can explain productivity (all aggregated at the household level using plot-size weights), and W_i is a vector of identifying instruments or exclusion restrictions that can be used for the selection equation. They include variables that one would not expect to have a direct effect on crop productivity, e.g., a household's social and political position in the community or assets not useful for production such as consumer durables and livestock other than oxen as explained in detail below.

The random error terms u_i, ε_{0i} and ε_{1i} are assumed to have a trivariate normal distribution with mean vector zero and a non-singular covariance matrix. As unobserved characteristics such as farming ability may directly affect productivity and the credit constrained status of the household, error terms may be correlated between selection and productivity equations. To avoid bias that might arise from neglecting such potential selectivity, we estimate parameters simultaneously using Full Information Maximum Likelihood (FIML) methods to address endogenous switching.[2]

Based on the above discussion, the signs of the estimated coefficients on different household endowments (land, labor and oxen), and liquidity may differ by regime. By definition, credit unconstrained households

[2] We use the "movestay" STATA command that implements the maximum likelihood method to estimate the endogenous switching regression model (Lokshin and Sajaia 2004).

will apply profit maximizing levels of inputs so that productivity will be independent of their endowments. If households are credit constrained, inputs will be used at less than the productivity-maximizing level and higher levels of liquidity would be associated with higher productivity of resource use. This implies that, at the margin, and to the extent that they do not affect credit constrained status, increases in certain factors may reduce rather than increase productivity in terms of output per hectare. For example, a marginal increase in operated land size could, for constrained households, reduce productivity due to its negative impact on the intensity of variable input use in the face of binding credit constraints. Similarly, the impact of changes in family labor endowments could have differential impacts depending on whether households are credit constrained or not and whether non-agricultural labor markets are accessible and function well.

3. Data and descriptive statistics

Explicit elicitation of different types of constraints in the fourth round of a longitudinal rural household survey in Ethiopia's Amhara region suggests that a large number of producers are credit constrained and that, in addition to supply-side considerations, high levels of risk are a key factor. While constrained and unconstrained farmers differ in predictable ways (e.g., unconstrained ones are more affluent), agricultural productivity is higher for unconstrained farmers only in one of the two regions. Being credit constrained is thus not always synonymous with failing to achieve full productive potential.

3.1 Sample and nature of data used

Our analysis is based on the fourth round of a longitudinal rural household survey in the Amhara region of Ethiopia's highlands conducted by the Ethiopian Development Research Institute (EDRI), Gothenburg University, and the World Bank in 2007. The survey includes information on demographics, resource endowments, agricultural production, and input, output, and credit markets participation for 1700 randomly selected households in 14 villages (*kebeles*) in six districts (*woredas*) in South Wollo and East Gojam zones of Amhara (Deininger *et al.* 2008). Information on agricultural production was collected for the main season (*meher*, i.e., September-February) of the 2007 agricultural year. We use data from 1587 households who engaged in crop production and have complete information on the variables of interest.

Observed loan applications and lenders' decisions and responses to qualitative questions on borrower's needs and perceptions are used to infer a households' semi-formal credit regime,[3] in line with previous studies on credit markets (Barham *et al.* 1996; Feder *et al.* 1990; Guirkinger and Boucher 2008; Jappelli 1990). Loan applicants were classified into three groups, namely those who had (i) applications fully or partly rejected (quantity rationed), (ii) received the requested amount but wanted to borrow more under

[3] Note that this method does not allow to measure the intensity of credit constraints (Diagne 1999).

the same terms (constrained, but cannot be classified as reasons for not applying for more were not asked), and (iii) had demand fully met (unconstrained). Those who had not applied were asked why they had not requested a loan and those who lacked interest because they had access to sufficient resources on their own or considered interest rates too high were classified as unconstrained or price rationed. The remainder was considered constrained in three ways, namely (i) those who reported fear of being indebted and the risk of losing collateral (risk rationed); (ii) those who stated lack of collateral and fear of being rejected were classified (quantity rationed); and (iii) those who lacked knowledge on how and where to apply or pointing towards lack of local credit supply (transaction cost rationed).

3.2 Descriptive evidence

Table 1 reports household-level rates of participation in the semi-formal and informal credit sector[4] by zone. With none of the households having used formal sources of loan, the semi-formal sector, defined to include service cooperatives, input suppliers, microfinance institutions, as well as non-governmental and governmental programs which provide subsidized loans to targeted groups of farmers, is by far the predominant source of loans. About a fourth (27% in Gojam and 20% in Wollo) of households reported having applied for a semi-formal loan in the 12 months preceding the survey. With some 3%, rejection rates were low and most applicants (72% in Gojjam and 88% in Wollo) obtained the amount that they requested. By comparison, the relevance of the informal sector, which comprises relatives, close friends, neighbors, moneylenders, and local organizations such as rotating savings and credit associations, was very low, both in terms of outreach and the size of resources transferred. Less than a tenth (10% in Gojjam and 4% in Wollo) of households in the sample applied for a loan from this sector. Although, with some 87% of requestors receiving the requested amount, rejection rates were small, average amounts received were only about one-tenth of the average loan received from the semi-formal sector.[5] The bottom panel of table 1 also points towards marked differences in loan use between the two regions. In Gojjam, one of the country's crop surplus producing areas, most farmers who received loans from the semi-formal sector (81%) used credit to purchase inputs or tools. By comparison, in Wollo, a food deficit area, more than half of the loans (56%) were used to purchase livestock, followed by consumption (16 %), and start-

[4] For a reasons such as the segmented nature of formal credit in many developing countries, a high ratio of transaction cost to potential loan size, inability to meet the collateral requirements of formal financial institutions, and high risk which, in the absence of insurance, makes it difficult to use future harvests as a guarantee to obtain formal loans, links to the formal sector are negligible in the sample. We thus do not consider this sector in our analysis.

[5] A study based on data from 15 villages in rural Ethiopia over the period of 1994-1995 showed that more than 94% of the applicant households obtained their loans from the informal sector with almost three-fourth of the loans were supplied by relatives and friends (Ayalew 2003). A similar pattern was observed for households surveyed in seven major urban centers in 2000. The results indicated that about 79% of the loans were made available by the informal sector and once again three-fourth of which was from relatives and friends (Ibrahim *et al.* 2007). Apparently, there seems to be a shift over the last decade in terms of loan suppliers from the informal towards that of the semi-formal sector.

up of off-farm activities (10%).[6] In both zones, informal loans are taken out mainly for consumption, including lumpy expenses for weddings and funerals.

Table 2 categorizes households who had and had not applied for loans by their credit constrained status in the semi-formal sector. With one-third being price rationed and thus unconstrained, some two-thirds of households overall were credit constrained. For those who had applied, about one-fifth were quantity rationed, i.e., had partially approved or fully rejected applications, while 7% got the full amount they asked for but would have wanted to borrow more at this rate. For non-applicants, risk rationing was by far the most important constraint, affecting about 60% of them in total, with the majority reporting a general fear of being indebted (95%) rather than a specific concern about losing collateral (5%). Somewhat more than a tenth of non-applicants claimed to be quantity rationed because of insufficient collateral and fear of being rejected. Only 2% reported to be transaction cost rationed due to lack of local supply or ignorance about how to apply loan. Finally, a fifth of non-applicants were unconstrained mainly because they had sufficient own resources (70%) and thus no need for a loan and the rest did not apply because the interest rate was too high for them to be able to develop economically feasible projects. This suggests that poorer households were more likely to be credit constrained.

Descriptive statistics in table 3 point towards marked differences between regions as well as constrained vs. unconstrained households. We note that 27% of households received a loan, 52% of unconstrained ones and 15% of constrained ones. With an average of ETB 220 (ETB 509 for the former vs. ETB 77 for the latter),[7] the size of what was received differed markedly between the two groups. Compared to the semi-formal sector, with total loans amounting less than ETB 25 an order of magnitude smaller than what could be accessed from semi-formal sources, the role of informal loans was marginal. While the general pattern is similar across the two regions, it is worth noting that, mainly due to larger loans taken out by unconstrained households, average loan sizes in the semi-formal sector are larger in Wollo than in Gojam.

Results also suggest that there are significant structural differences, in terms of resource endowments and economic opportunities, between the two zones. This may imply a need for investigating the impact of credit constraints on crop productivity separately in each of them. Regarding general household characteristics, the wealth differential between constrained and unconstrained households is about 33% for livestock (excluding oxen) and 41% for other household assets (including housing).[8] At the same time, the size of land owned does not vary significantly by credit market status, possibly due to Ethiopia's land

[6] However, information is not available on the type of livestock to be able to check whether it had some direct link with crop production bearing the fact that oxen is the most important source of draught power in the cereal cultures of the country that includes both Gojjam and Wollo zones.
[7] To put this in perspective, note that at the time of our survey, the exchange rate was about ETB 8 per US$.
[8] The two groups can also be distinguished by their endowment with oxen, the most important source of draught power in the survey areas: credit unconstrained households own about 20% more oxen than constrained ones, though—with the exception of unconstrained households in Gojjam who, on average, own 2.21 oxen per household—both groups own on average less than a pair.

tenure system that is characterized by land being state property and usufruct rights allocated by local authorities largely on the basis of family size. Between the zones, land is more abundant in Gojjam than in Wollo with 1.72 and 0.99 hectares per household, respectively. The fact that there are marked differences in terms of cultivated area between unconstrained and constrained households (2.10 and 1.21 ha in Gojam and Wollo for unconstrained ones and 1.83 and 1.03 ha for constrained ones), could imply that working capital constraints limit the amount of area that can actually be cultivated.

Differences between the zones in terms of oxen ownership are also pronounced; on average households in Gojjam own about two oxen while those in Wollo own about one ox per household. As technology requires use of a pair of oxen for plowing and oxen rental is generally impractical due to moral hazard (Binswanger and Rosenzweig 1986), the only alternative of sharing oxen makes it difficult to respond to the seasonal nature of agricultural activities in a timely manner. Also, households in Wollo earn significantly more income from off-farm activities, with unconstrained households earning more from off-farm activities than constrained ones and participation rates more than double to those in Gojjam.

Analysis of the effect of being credit constrained on crop productivity is also of interest. Again, we note significant differences between the two zones: in Gojam, the value of crop output per hectare is significantly higher for unconstrained (ETB 3163) than constrained (ETB 2480) households as expected if credit is important to finance agricultural production, e.g., through working capital. The reverse is true for Wollo where unconstrained households obtain (ETB 2641/ha) less than constrained ones (ETB 2866/ha). This is surprising as key plot characteristics such as subjective soil quality, slope, access to irrigation, length of possession do not differ significantly between the two groups. Econometric analysis with proper controls for credit constrained status will thus be of interest.

An interesting feature from the data is that unconstrained households participate much more in local institutions and are thus socially better connected. The fraction of households with at least one family member holding an official and/or party position is about 60% higher among unconstrained households than constrained ones (32% vs. 20%). Large differences between unconstrained and constrained households emerge also in terms of membership in service cooperatives (27% vs. 17%) and microfinance institutions (24% vs. 10%).

Comparing resource endowments and input intensity between regions and constrained or unconstrained households points towards key differences in terms of technology that gives initial insight on potential spatially differentiated impacts of credit constraints on productivity (table 4). Operated land is larger than owned land for all households, pointing to an active rental markets whereby producers obtain land from non-producing households. Unconstrained households cultivated 0.25 hectares more than constrained ones, largely due to the impact of rental markets which transfer land from poor female-headed households

to wealthier farmers (Deininger *et al.* 2011) who are more likely to be credit unconstrained. While the labor to land ratio does not systematically vary, the oxen to land ratio is higher for unconstrained households and even higher in Wollo than in Gojjam due to land scarcity in this zone. Technology also differs between the regions: while Wollo farmers use hardly any fertilizer and a more labor- and oxen-intensive technology, most Gojam households apply chemical fertilizer (76% vs. 94% for constrained and unconstrained households, respectively). Labor and oxen use per hectare are higher for unconstrained than constrained farmers in Gojjam, but not in Wollo where the reverse is true and where significantly more manure is applied (with no immediate impact of credit constrained status). Descriptive figures thus point towards systematic differences in the crop production structure between the two zones, and hence reinforce the call for the empirical analysis is to be done separately for the two zones.

4. Econometric results

Use of FIML to estimate the endogenous switching regression model in a way that accounts for the endogeneity of being credit constrained allows us to quantify the impact of credit constraints in the two regions. Estimates suggest that, in addition to resource endowments and wealth, political and social connections are key determinants of a household's credit constrained status. Productivity-impacts vary significantly across regions; while a clear link between credit constraints and productivity is evident for the more commercially oriented part of our sample, we find no evidence of such a relationship for the more subsistence-oriented region. This suggests eliminating credit constraints will have a strong productivity impact only if attractive investment opportunities exist. Removal of all credit constraints is estimated to increase productivity by some 11 percentage points. Together, our findings suggest that efforts to make credit available without addressing more structural factors may have limited impact.

4.1 Determinants of credit rationing

The parameters of the endogenous switching regression model of equations (1-3) are estimated by Full Information Maximum Likelihood (FIML). Dependent variables are the log of the value of crop output per hectare and the binary indicator of whether the household is constrained or not in the semi-formal sector as discussed. We estimate two specifications; a semi-log and a partial log-linear specification where land size is in log form. Results from the two specifications are consistent within the pooled (table 5) and individual zonal samples (tables 6 and 7). The likelihood test of independence of error terms in the system of equations (1-3) is rejected, supporting the endogenous sample separation and the use of a FIML estimation strategy.

In addition to the independent variables in the productivity regression, the selection equation includes two sets of identifying instrumental variables expected to affect productivity only through their impact on

households' credit constrained status. Based on the notion that wealth helps alleviate credit constraints, a first set of indicators includes non-agricultural wealth such as the value of livestock (excluding oxen) and household assets not directly used in crop production. The second set of instruments is based on the conjecture that political power and social connections in the village economy make it easier to access credit, e.g., by improving information or access to loans channeled through local structures, independently of the ability to use such credit productively. We use three indicator variables for these; namely, (i) whether a member holds a leadership position, including an executive position in the local administration or is a member of the village council, the land administration committee, or the ruling party; (ii) whether a member participated in farmers' service cooperatives, unions or microfinance institutions; and (iii) the number of adult children with their own household in the same village.

In light of the marked structural differences between regions, we report results for separate estimates from Gojam and Wollo in tables 6 and 7, respectively, following the results from the pooled sample reported in table 5. In each case, model 2 has land owned in logarithms while model 1 has it in absolute area. Columns 3 and 6 of tables 5, 6 and 7 suggest that the exclusion variables are strong predictors of households' credit constrained status but that their impact differs by location. In the aggregate, the most important predictors of being credit unconstrained are membership in micro-finance institutions, party membership or political position, and the value of other livestock, in addition to oxen and a dummy for Wollo. The relevance of these varies somewhat across regions; parameter estimates of all the variables, except membership in service cooperatives for Gojjam, are positive and jointly significantly different from zero implying that strong socio-political position and wealth of households significantly reduce the probability of being credit constrained in the semi-formal sector.[9]

4.2 Credit access and productivity of resource use

In the model for the full sample (table 5), the number of oxen has a positive coefficient and is significant in explaining the variation in the value of crop output per hectare for constrained but not for unconstrained households. It suggests that credit constrained farmers have a positive shadow price for oxen as expected under imperfectly operating oxen rental market and imperfect capital markets that make it impossible to afford the high up-front investment needed to acquire a full pair of oxen in the subsistence environment at hand. Lack of oxen seems to prevent credit constrained households from realizing their full potential in terms of agricultural productivity. On the other hand, neither constrained nor unconstrained households seem to gain from better access to family labor as would be expected in a

[9] Similar to previous results for smallholder dairy farmers in Ethiopia (Freeman *et al*. 1998), resource endowments are found to be important in explaining the likelihood of credit constraints status of households in our survey villages that are mainly involved in crop production. We would like to underline that this study introduces additional variables that measure the social and political position of households in the local community that are also found to have significant effects in the selection equation.

setting with imperfect off-farm employment opportunities. Coefficients on soil quality and slope have the expected signs and are jointly significant. At the same time, estimates suggest that, counter-intuitively, the value of output per hectare is independent of total liquidity as well as a household's credit constrained status. Also, contrary to expectations, the value of output per hectare is decreasing in the household's land endowment for both types of households. This could be explained by high transaction costs and other land rental market imperfections that could prevent households from attaining their optimum operational holding size (Deininger *et al.* 2008). It may, however, also be due to the fact that the estimates pool two zones that are characterized by significant structural differences.

Reporting results from estimating the relevant regressions separately for the two zones (table 6 for Gojjam and table 7 for Wollo) allows us to explore relevant factors in more detail. In Gojam, clear differences emerge between credit constrained and unconstrained households in several instances. For example, while the shadow value of liquidity is estimated to be positive throughout, in line with the literature (Guirkinger and Boucher 2008), liquidity is estimated to have a large positive effect on crop productivity by credit constrained farmers but is only marginally significant, and has a significantly smaller coefficient (0.08 vs. 0.22), for unconstrained ones.[10] Soil quality increases productivity irrespectively of whether or not the farmer suffers from a binding credit constraint. Consistent with the prediction of the underlying model, production factor endowments (land, oxen and labor) significantly affect crop productivity with all of them having the right sign for constrained farmers. For these farmers, having constrained access to liquidity, increasing land endowment would lower the intensity of variable input use per hectare and hence would lower crop productivity significantly. According to the log linear estimates (given in column 4), a one percent increase in the amount of land owned would lower the value of crop output per hectare by about 20%. In contrast, an increase in the number of oxen and male adults leads to an increase in productivity on the constrained regression. Given that unconstrained households are expected to operate at their optimal level, their crop productivity is not affected by marginal change in production factor endowments.

To quantify the productivity losses from being affected by a binding credit constraint, we can use the standard approach in the literature of "treatment effects" (Guirkinger and Boucher 2008) which computes the predicted impact of removing the credit constraint for constrained households as:

$$\hat{\Delta} y_i = (\hat{\beta}_1 - \hat{\beta}_0)' X_i + (\hat{\gamma}_1 - \hat{\gamma}_0)' Z_i$$

[10] The fact that productivity is affected, though marginally, by a change in liquidity on unconstrained equation might be a cause for concern about the existence of endogeneity problem that would lead to simultaneity bias on the magnitude of estimated coefficients (Feder *et al.* 1990). The confidence on the overall performance of the model relies on the fact that the magnitude is significantly smaller for unconstrained households.

where $\hat{\beta}$ and $\hat{\gamma}$ are the estimated parameters for constrained and unconstrained households respectively (i.e., table 6, col. 1 and 2). Using these numbers suggests that, on average, removal of all types of credit constraints would result in an increase of the value of output per hectare by Birr 237, an 11.4% increase over constrained households' observed level of productivity.

In contrast to clear effects of credit constraints on resource allocation and productivity in Gojam, evidence from the endogenous switching regressions does not suggest any impact along these lines in Wollo. To the contrary, liquidity is estimated to have a marginally significant negative effect on productivity for unconstrained farmers. Also, the amount of land owned is estimated to negatively affect crop productivity of both constrained and unconstrained farmers.[11] As households in Wollo used loans for livestock rather than crop farming and off-farm income was a more important predictor of being credit constrained, crop productivity may not be the most relevant variable to consider. Still, our evidence clearly suggests that efforts to improve credit access for Wollo farmers will not raise agricultural productivity. More generally, our results highlight that determinants and effects of credit constraints are location-specific and that policy prescriptions that fail to take this specificity into account might be misleading.

5. Conclusions and policy implications

While lack of access to formal credit is frequently described as a key problem for smallholder farmers in rural Ethiopia (Croppenstedt *et al.* 2003; Dercon and Christiaensen 2011), few studies explore the extent and nature of credit rationing that might underlie this phenomenon and its productivity impacts. To answer these questions in a setting with no access to formal loans, we focus on the semi-formal sector and use a survey-based direct elicitation approach to identify supply- and demand-side constraints faced by potential borrowers. Three findings are relevant. First, although quantity rationing is not negligible, risk is by far the most common reason for being credit constrained in the semi-formal sector. In fact, with almost half the sample households risk rationed, an exclusive focus on supply-side constraints could be misguided. Finding ways to address exposure to uninsured risk by smallholders would likely reduce the incidence of credit rationing. Second, political and social networks emerge as key determinants of credit access, pointing towards a need to further explore the implications for the effectiveness and targeting of public programs in this area. Finally, credit rationing affected agricultural productivity in a surplus-producing zone where loans were used mainly for purchasing agricultural inputs and the removal of credit constraints is estimated to increase productivity by 11.4 percentage points. On the other hand, crop productivity is estimated to be unaffected by credit constraints in a more drought-prone and food insecure zone where loans are used for purposes, mainly purchase of livestock, other than crop production. Finally,

[11] While the difference is not different from zero at conventional significance levels, the point estimate of the absolute magnitude is almost double for the latter than the former.

recent developments in terms of the traits, availability and coverage of semi-formal finance warrants further research in the area.

Table 1: Loan Applications and use of loans (for recipients only) by source and zone

		Semi-formal			Informal	
	Total	**Gojjam**	**Wollo**	**Total**	**Gojjam**	**Wollo**
Loan application/participation						
Applied for loan	0.23	0.27	0.20	0.07	0.10	0.04
If yes, fully approved	0.79	0.72	0.88	0.87	0.86	0.89
If yes, partially approved	0.17	0.24	0.10	0.09	0.10	0.08
If yes, rejected	0.03	0.04	0.02	0.04	0.04	0.03
Number of households applied for loan	364	197	167	109	71	38
Total number of households	1587	741	846	1587	741	846
Reasons for loan application (recipients only)						
Buy ag. tools, implements and inputs	0.47	0.81	0.07	0.29	0.40	0.08
Buy livestock	0.35	0.17	0.56	0.08	0.10	0.05
Start off-farm business	0.04	0.01	0.10	0.08	0.08	0.05
Buy food and other consumption items	0.08	0.01	0.16	0.17	0.18	0.16
Buy construction materials	0.03	0.01	0.06	0.07	0.02	0.14
Pay for health and education expenses	0.01	0.01	0.01	0.16	0.09	0.30
Other: travel, wedding, funeral, etc.	0.03	0.01	0.04	0.17	0.15	0.22
Number of households	352	189	163	105	68	37

Source: Own computation from AAU/Gothenburg/WB survey 2006/07.

Note: None of the sampled households applied for a loan in the formal sector during the time to the survey.

Table 2: Households' status in the semi-formal credit market by rationing mechanism

Rationing mechanism	Entire sample			Gojam			Wollo		
	Total	Applied?		Total	Applied?		Total	Applied?	
		No	Yes		No	Yes		No	Yes
Percentage share		77.06	22.94		73.41	26.59		80.26	19.74
Type of rationing									
Price rationed/unconstrained	0.33	0.22	0.72	0.31	0.18	0.66	0.35	0.25	0.79
Risk rationed	0.46	0.60		0.45	0.61		0.47	0.58	
Quantity rationed[a]	0.14	0.11	0.21	0.17	0.13	0.28	0.11	0.10	0.12
Transaction cost rationed	0.02	0.02		0.02	0.03		0.02	0.02	
Uncategorized, yet constrained[b]	0.05	0.05	0.07	0.05	0.05	0.06	0.06	0.05	0.09
Number of households	1587	1223	364	741	544	197	846	679	167

Source: Own computation from AAU/Gothenburg/WB survey 2006/07.

Note: [a] For applicants, quantity rationed households include those whose applications were partially approved or fully rejected. Of the partially approved ones, only 16% (12 out of 75), 14.6% (8 out of 55), and 20% (4 out of 20) were quantity rationed in the pooled, Gojjam and Wollo samples, respectively. As shown in table 1, very few loans in the sample were fully rejected.

[b] Uncategorized applicants are those who received the full amount they requested but still wanted to borrow more at prevailing loan terms.

Table 3: Household level characteristics by semi-formal credit market participation status

	Entire sample			Gojjam only			Wollo only		
	Total	**Cons.**	**Uncons.**	**Total**	**Cons.**	**Uncons.**	**Total**	**Cons.**	**Uncons.**
Credit market participation									
Received loan?	0.27	0.15	0.52	0.32	0.20	0.58	0.23	0.09	0.47
Amount of credit received (B)	244.57	105.28	524.74	200.18	117.17	386.94	283.45	94.13	629.81
Loan from semi-formal sector?	0.22	0.08	0.50	0.26	0.12	0.57	0.19	0.06	0.44
If yes, amount received (B)	220.41	76.82	509.23	166.77	77.98	366.55	267.40	75.73	618.04
Loan from informal sector?	0.07	0.07	0.06	0.09	0.10	0.07	0.04	0.04	0.05
If yes, amount received (B)	24.16	28.46	15.50	33.41	39.19	20.39	16.06	18.40	11.77
Endowments									
No. of male adults	1.77	1.72	1.87	1.76	1.70	1.89	1.78	1.74	1.86
No. of female adults	1.63	1.61	1.67	1.59	1.57	1.66	1.66	1.65	1.68
No. of oxen owned	1.49	1.38	1.70	1.81	1.63	2.21	1.20	1.15	1.31
Part. in off-farm activities?	0.50	0.48	0.53	0.36	0.38	0.33	0.62	0.58	0.68
Non-farm income (B)	699.54	607.93	883.81	399.46	406.46	383.69	962.39	796.88	1265.17
Head's age (years)	50.92	51.75	49.23	49.84	50.31	48.78	51.86	53.10	49.57
Head's education (years)	1.01	0.90	1.23	0.75	0.79	0.65	1.24	1.01	1.67
Head is literate	0.35	0.32	0.41	0.36	0.33	0.41	0.34	0.30	0.41
No. of members below age 15	2.27	2.20	2.41	2.46	2.42	2.56	2.11	2.00	2.30
Land ownership and plot characteristics									
Own land in hectares	1.33	1.33	1.35	1.73	1.72	1.75	0.99	0.95	1.04
Total operated area (ha)	1.48	1.42	1.59	1.91	1.83	2.10	1.09	1.03	1.21
Crop output per hectare (B)	3017.99	2943.54	3167.41	2690.37	2480.37	3162.88	3304.94	3377.92	3171.41
Proportion good soil quality	0.56	0.56	0.57	0.43	0.43	0.43	0.67	0.67	0.68
Proportion medium soil quality	0.32	0.32	0.32	0.36	0.35	0.38	0.28	0.28	0.27
Proportion flat	0.72	0.72	0.72	0.69	0.70	0.68	0.75	0.75	0.74
Proportion gently sloped	0.23	0.22	0.23	0.25	0.24	0.26	0.21	0.21	0.21
Proportion irrigated	0.07	0.07	0.07	0.04	0.04	0.03	0.11	0.11	0.11
Years possessed	19.25	19.45	18.86	18.74	18.87	18.43	19.71	19.99	19.18
Identifying instruments									
Value of household assets (B)	8104.51	7142.56	10039.36	4740.12	4406.16	5491.54	11051.33	9708.87	13507.27
Value of livestock (excl oxen)	3622.00	3256.67	4356.81	4326.31	3777.50	5561.12	3005.10	2768.20	3438.48
No. of adult children	1.34	1.37	1.27	1.40	1.39	1.42	1.28	1.34	1.16
A member held /party position	0.24	0.20	0.32	0.23	0.20	0.32	0.24	0.20	0.31
Member of service coop	0.20	0.17	0.27	0.20	0.18	0.24	0.21	0.17	0.29
Member of microfinance inst.	0.14	0.10	0.24	0.13	0.09	0.22	0.16	0.10	0.25
Number of observations	1587	1060	527	741	513	288	846	547	299

Source: Own computation from AAU/Gothenburg/WB survey 2006/07.

Table 4: Intensity of Input Use and Resource Endowment by Credit Market Participation Status

	Entire sample			Gojjam only			Wollo only		
	Total	**Cons.**	**Uncons.**	**Total**	**Cons.**	**Uncons.**	**Total**	**Cons.**	**Uncons.**
Endowment ratios									
Cult. area for select crops (ha)	1.32	1.26	1.44	1.80	1.71	2.02	0.90	0.84	1.00
Male adults per ha owned land	1.92	1.90	1.96	1.26	1.26	1.28	2.49	2.50	2.48
Female adults ha of owned land	1.83	1.80	1.90	1.18	1.18	1.17	2.40	2.38	2.45
Oxen owned per ha owned land	1.45	1.36	1.62	1.26	1.16	1.49	1.61	1.55	1.72
Intensity of input use									
Used fertilizer?	0.41	0.39	0.45	0.82	0.76	0.94	0.06	0.05	0.08
Quantity (kg/ha)	31.03	29.16	34.78	63.23	58.10	74.76	2.82	2.01	4.29
Used manure?	0.70	0.69	0.71	0.58	0.58	0.58	0.80	0.79	0.80
Quantity (kg/ha)	591.77	542.04	691.79	138.96	147.51	119.71	988.38	912.05	1128.03
Used pesticides?	0.13	0.12	0.16	0.22	0.18	0.31	0.05	0.05	0.04
Quantity (kg/ha)	0.30	0.19	0.52	0.38	0.11	0.98	0.22	0.26	0.16
Oxen days (pair/ha)	20.99	21.34	20.30	18.02	17.66	18.84	23.59	24.78	21.42
Male family days/ha	113.77	116.48	108.31	60.63	58.81	64.73	160.31	170.57	141.54
Female family days/ha	59.83	60.01	59.47	31.55	31.49	31.68	84.60	86.76	80.66
Hired labor?	0.26	0.24	0.31	0.29	0.25	0.37	0.24	0.22	0.26
Hired labor days/ha	5.52	5.37	5.81	2.62	2.16	3.68	8.05	8.39	7.44
Number of observations	1587	1060	527	741	513	288	846	547	299

Source: Own computation from AAU/Gothenburg/WB survey 2006/07.

Table 5: FIML estimate of switching regression: Effects of credit constraint on crop productivity (pooled)

	Model 1			Model 2		
	Constrained	**Unconstrained**	**Selection**	**Constrained**	**Unconstrained**	**Selection**
Liquidity x 10^3	0.060	-0.010		0.069	-0.011	
	(1.247)	(-0.191)		(1.423)	(-0.241)	
Owned land in hectares	-0.122***	-0.082**	-0.050	-0.192***	-0.173**	0.011
(log in model 2)	(-4.451)	(-2.194)	(-1.216)	(-4.627)	(-2.450)	(0.187)
Number of male adults	0.021	0.059	0.060*	0.023	0.065*	0.057
	(0.899)	(1.557)	(1.660)	(1.011)	(1.807)	(1.594)
Number of female adults	-0.026	0.042	0.038	-0.025	0.042	0.032
	(-0.950)	(1.228)	(0.899)	(-0.922)	(1.301)	(0.765)
Number of oxen owned	0.114***	0.032	0.096**	0.114***	0.038	0.083**
	(4.568)	(0.517)	(2.464)	(4.580)	(0.852)	(2.158)
Value of non-farm income x 10^3	-0.010	-0.019	0.035*	-0.011	-0.020	0.038*
	(-0.523)	(-0.790)	(1.665)	(-0.573)	(-0.871)	(1.801)
Age of household head	0.002	-0.027**	-0.006	0.002	-0.025**	-0.009
	(0.209)	(-2.163)	(-0.364)	(0.197)	(-1.964)	(-0.525)
Age of hh head squared x 10^2	-0.005	0.022*	-0.003	-0.005	0.020	-0.001
	(-0.464)	(1.763)	(-0.197)	(-0.439)	(1.639)	(-0.079)
Formal education by head (years)	-0.009	0.016	0.006	-0.010	0.018	0.005
	(-0.982)	(1.343)	(0.405)	(-0.988)	(1.624)	(0.342)
No of hh members < age 15	-0.007	0.021	-0.005	-0.003	0.029	-0.008
	(-0.426)	(0.979)	(-0.191)	(-0.184)	(1.459)	(-0.319)
Share of good soil quality land	0.449***	0.493***		0.458***	0.520***	
	(4.836)	(3.342)		(4.951)	(3.588)	
Proportion of medium soil quality land	0.240**	0.543***		0.232**	0.544***	
	(2.234)	(3.624)		(2.165)	(3.708)	
Proportion of flat land	0.348*	0.362		0.342*	0.360	
	(1.779)	(1.583)		(1.752)	(1.561)	
Proportion of gently sloped land	0.219	0.252		0.223	0.270	
	(1.105)	(1.110)		(1.125)	(1.186)	
Proportion of irrigated land	0.141	-0.085		0.152	-0.090	
	(1.406)	(-0.439)		(1.527)	(-0.486)	
Number of years possessed	-0.006**	-0.001		-0.006**	-0.001	
	(-2.029)	(-0.324)		(-2.124)	(-0.350)	
Wollo zone dummy	0.124**	-0.258***	0.155*	0.108*	-0.286***	0.193**
	(2.246)	(-2.815)	(1.955)	(1.947)	(-3.355)	(2.404)
Value of household assets x 10^3			0.005*			0.004*
			(1.793)			(1.679)
Value of other livestock x 10^3			0.042***			0.041***
			(3.384)			(3.236)
Adult children in village			0.022			0.020
			(1.424)			(1.343)
Member has a political position			0.180**			0.180**
			(2.214)			(2.216)
Member of service cooperative			0.140			0.136
			(1.569)			(1.572)
Member of microfinance inst.			0.604***			0.612***
			(5.876)			(6.339)
Sigma	0.745	0.656		0.745	0.646	
Rho	-0.423	-0.124		-0.418	-0.084	
Log-Likelihood		-2,599.92			-2,588.23	
chi2		136.681			131.947	
LR test of independent equations		15.531			14.992	
χ^2 of equality of liquidity coef.		0.75			0.05	
Prob>chi2		0.385			0.816	
Number of observations		1,586			1,582	

Note: Robust t statistics in parentheses; *, **, and *** denote significance at 10%; 5%; 1%. Constant included but not reported.

Table 6: FIML estimate of switching regression model: Effects of credit constraint on crop productivity (Gojam Sample)

	Model 1			Model 2		
	Constrained	**Unconstrained**	**Selection**	**Constrained**	**Unconstrained**	**Selection**
Liquidity x 10^3	0.218***	0.080*		0.227***	0.080*	
	(3.185)	(1.761)		(3.285)	(1.761)	
Owned land in hectares	-0.113***	-0.015	-0.144***	-0.189***	0.054	-0.139
(log in model 2)	(-3.017)	(-0.399)	(-2.632)	(-2.761)	(0.698)	(-1.399)
Number of male adults	0.061*	0.035	0.059	0.062*	0.031	0.057
	(1.682)	(0.819)	(1.086)	(1.690)	(0.738)	(1.040)
Number of female adults	-0.006	-0.004	0.076	-0.009	-0.009	0.063
	(-0.159)	(-0.105)	(1.148)	(-0.210)	(-0.235)	(0.950)
Number of oxen owned	0.150***	0.050	0.127**	0.145***	0.040	0.107*
	(4.357)	(1.595)	(2.276)	(4.260)	(1.309)	(1.938)
Value of non-farm income x 10^3	-0.010	0.010	0.004	-0.012	0.010	0.004
	(-0.290)	(0.427)	(0.074)	(-0.320)	(0.457)	(0.071)
Age of household head	-0.021	-0.034**	-0.006	-0.020	-0.037**	-0.009
	(-1.349)	(-1.994)	(-0.215)	(-1.254)	(-2.132)	(-0.345)
Age of hh head squared x 10^2	0.015	0.025	-0.004	0.015	0.027	-0.001
	(1.088)	(1.528)	(-0.153)	(1.024)	(1.627)	(-0.058)
Formal education by head (years)	-0.016	-0.001	-0.039	-0.016	0.001	-0.037
	(-1.069)	(-0.070)	(-1.517)	(-1.038)	(0.071)	(-1.475)
No of hh members < age 15	0.002	0.019	-0.014	0.004	0.016	-0.014
	(0.061)	(0.794)	(-0.366)	(0.159)	(0.657)	(-0.362)
Share of good soil quality land	0.625***	0.741***		0.627***	0.740***	
	(5.817)	(4.825)		(5.813)	(4.844)	
Share of medium quality land	0.280**	0.766***		0.272**	0.765***	
	(2.016)	(4.639)		(1.967)	(4.658)	
Proportion of flat land	0.349	0.235		0.350	0.216	
	(1.146)	(1.158)		(1.141)	(1.070)	
Proportion of gently sloped land	0.270	0.090		0.278	0.078	
	(0.874)	(0.448)		(0.894)	(0.388)	
Proportion of irrigated land	0.052	-0.097		0.073	-0.082	
	(0.432)	(-0.757)		(0.603)	(-0.598)	
Number of years possessed	-0.007*	0.004		-0.008*	0.004	
	(-1.663)	(1.037)		(-1.770)	(0.852)	
Value of household assets x 10^3			0.028*			0.030**
			(1.869)			(2.060)
Value of other livestock x 10^3			0.050***			0.049***
			(3.411)			(3.385)
Adult children in village			0.038*			0.035*
			(1.822)			(1.707)
Member has a political position			0.211*			0.208*
			(1.704)			(1.691)
Member of service cooperative			-0.042			-0.050
			(-0.318)			(-0.384)
Member of microfinance inst.			0.676***			0.668***
			(4.895)			(4.868)
Sigma	0.725	0.480		0.732	0.481	
Rho	-0.463	0.236		-0.480	0.255	
Log-Likelihood		-1,100.66			-1,104.89	
chi2		111.009			109.679	
LR test of independent equations		18.589			20.318	
χ^2 of equality of liquidity coef.		2.80			3.19	
Prob>chi2		0.094			0.074	
Number of observations		740			740	

Note: Robust t statistics in parentheses; *, **, and *** denote significance at 10%; 5%; 1%. Constant included but not reported.

Table 7: FIML estimate of switching regression model: Effects of credit constraint on crop productivity (Wollo Sample)

	Model 1			Model 2		
	Constrained	**Unconstrained**	**Selection**	**Constrained**	**Unconstrained**	**Selection**
Liquidity x 10^3	-0.089	-0.101*		-0.085	-0.099*	
	(-1.398)	(-1.849)		(-1.287)	(-1.830)	
Owned land in hectares	-0.137***	-0.256***	0.062	-0.171***	-0.337***	0.061
(log in model 2)	(-2.944)	(-3.137)	(0.859)	(-3.151)	(-3.199)	(0.755)
Number of male adults	0.003	0.038	0.056	0.005	0.040	0.057
	(0.105)	(0.690)	(1.182)	(0.158)	(0.717)	(1.200)
Number of female adults	-0.038	0.074	-0.002	-0.036	0.072	-0.002
	(-0.997)	(1.326)	(-0.033)	(-0.959)	(1.322)	(-0.041)
Number of oxen owned	0.034	-0.005	0.050	0.039	0.010	0.043
	(0.870)	(-0.067)	(0.853)	(0.976)	(0.128)	(0.737)
Value of non-farm income x 10^3	-0.016	-0.043	0.044*	-0.017	-0.044	0.047**
	(-0.657)	(-1.587)	(1.919)	(-0.692)	(-1.588)	(2.017)
Age of household head	0.016	-0.022	0.004	0.016	-0.016	0.003
	(0.966)	(-1.044)	(0.187)	(0.971)	(-0.740)	(0.157)
Age of hh head squared x 10^2	-0.016	0.024	-0.012	-0.016	0.019	-0.011
	(-1.032)	(1.152)	(-0.585)	(-1.034)	(0.914)	(-0.571)
Formal education by head (years)	-0.005	0.006	0.031*	-0.005	0.009	0.028
	(-0.352)	(0.305)	(1.724)	(-0.359)	(0.529)	(1.564)
No of hh members < age 15	0.002	-0.002	0.024	0.006	0.010	0.019
	(0.103)	(-0.046)	(0.709)	(0.297)	(0.274)	(0.585)
Share of good soil quality land	-0.023	0.016		-0.021	0.137	
	(-0.113)	(0.061)		(-0.105)	(0.528)	
Share of medium quality land	-0.159	0.014		-0.171	0.079	
	(-0.730)	(0.053)		(-0.786)	(0.308)	
Proportion of flat land	0.475**	0.480		0.464**	0.428	
	(2.231)	(1.578)		(2.183)	(1.394)	
Proportion of gently sloped land	0.335	0.429		0.330	0.405	
	(1.504)	(1.427)		(1.482)	(1.334)	
Proportion of irrigated land	0.265**	-0.099		0.260*	-0.132	
	(1.974)	(-0.509)		(1.950)	(-0.681)	
Number of years possessed	-0.004	-0.006		-0.003	-0.007	
	(-0.777)	(-1.042)		(-0.734)	(-1.356)	
Value of household assets x 10^3			0.004*			0.004*
			(1.700)			(1.700)
Value of other livestock x 10^3			0.031**			0.032**
			(2.182)			(2.273)
Adult children in village			0.020			0.019
			(1.185)			(1.172)
Member has a political position			0.120			0.110
			(1.349)			(1.230)
Member of service cooperative			0.234**			0.241***
			(2.492)			(2.607)
Member of microfinance inst.			0.401***			0.390***
			(2.904)			(2.710)
Sigma	0.782	0.968		0.779	0.964	
Rho	-0.586	-0.803		-0.574	-0.821	
Log-Likelihood		-1,429.55			-1,415.94	
chi2		31.553			33.267	
LR test of independent equations		19.309			17.177	
Number of observations		846			842	

Note: Robust t statistics in parentheses; *, **, and *** denote significance at 10%; 5%; 1%. Constant included but not reported.

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