WPS6769

Policy Research Working Paper 6769

Credit Constraints, Agricultural Productivity, and Rural Nonfarm Participation

Evidence from Rwanda

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February 2014

Abstract

Although the potentially negative impacts of credit constraints on economic development have long been discussed conceptually, empirical evidence for Africa remains limited. This study uses a direct elicitation approach for a national sample of Rwandan rural households to assess empirically the extent and nature of credit rationing in the semi-formal sector and its impact using an endogenous sample separation between credit-constrained and unconstrained households. Being credit constrained reduces the likelihood of participating in off-farm self-employment activities by about 6.3 percent while making participation in low-return farm wage labor more likely. Even within agriculture, elimination of all types of credit constraints in the semi-formal sector could increase output by some 17 percent. Two suggestions for policy emerge from the findings. First, the estimates suggest that access to information (education, listening to the radio, and membership in a farm cooperative) has a major impact on reducing the incidence of credit constraints in the semi-formal credit sector. Expanding access to information in rural areas thus seems to be one of the most promising strategies to improve credit access in the short term. Second, making it easy to identify land owners and transfer land could also significantly reduce transaction costs associated with credit access.

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Credit constraints, agricultural productivity, and rural nonfarm participation: Evidence from Rwanda

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JEL classification: D82, O13, O16

Keywords: Crop production; Credit constraints; Credit rationing; Activity choice; Rwanda

Sector board: Agriculture and Rural Development (ARD)

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[§] The authors would like to thank the UK Department for International Development, the Global Land Tools Network and the Knowledge for Change Program for funding support, Rodney Dyer, Sion McGeever, and Cyriaque Harelimana for initiating and supporting data collection as well as the National Land Centre (now Rwanda National Resource Authority) in Kigali, especially Emmanuel Nkurunziza and Didier Sagashya. They are grateful to Sylvie Lambert, Will Martin and Zurab Sajaia for useful comments as well as the seminar participants at LICOS, at the Paris School of Economics and at the University of Johannesburg, as well as participants in the CSAE 2012 conference and the IGC Growth Week 2012. The views presented in this paper are those of the authors and do not represent those of the World Bank or its member countries or of the International Growth Centre.

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1. Introduction

The potential negative impact of capital market imperfections and credit rationing in developing countries has long been recognized at a conceptual level (for example, Stiglitz and Weiss, 1981; Eswaran and Kotwal, 1986; Carter, 1988; Kochar, 1997). In an economy with perfect markets, activity choice should be based on households' comparative advantages and wages independently from their endowments. But with market imperfections, this will no longer hold and households may choose portfolios with low returns just because they are less risky. Many studies document that production organization and resource use in smallholder agriculture are affected by credit market imperfections (Bell, 1988; Carter, 1988; Conning and Udry, 2007). Credit rationing can possibly explain that, in African agriculture, high returns to capital coexist with very low levels of purchased input use (Carter and Wiebe, 1990), possibly because insurance market difficulties reduce households' willingness to invest in high-return but high-risk activities (Eswaran and Kotwal, 1990). Beyond agricultural productivity, credit constraints may affect rural development more broadly by preventing households from taking up nonagricultural activities which many studies have identified as a key for structural transformation and households' ability to move out of poverty (Reardon, 1997; Ellis, 2000). However, empirically identifying who is credit constrained poses challenges. Direct elicitation has been suggested to identify credit constrained households and distinguish between supply- and demand-side factors (Boucher et al., 2008).

Against this background, this paper contributes to the literature by using direct elicitation methods for a nationally representative sample from Rwanda, one of Africa's most densely populated countries, to identify households' credit constraint status. With credit market imperfections, households' ability to make the best use of inputs in agriculture or their portfolio of activities will vary significantly between those who are credit constrained and those who are not. For the former, but not for the latter, productivity and the ability to invest in off-farm self-employment will depend on wealth and liquidity. While a number of studies have explored this in the context of agricultural production, to our knowledge, very few empirical works focus on assessing empirically the impact of credit constraints on income diversification choices.

Descriptive evidence from our national sample suggests that formal credit is virtually nonexistent and informal borrowing remains minuscule (USD 34 per year on average). We thus focus on the semi-formal sector (cooperatives, input suppliers, micro-finance institutions, and NGOs) as the relevant source of

credit supply. The data show that more than two-thirds of households (71 percent) are credit rationed overall and that the incidence of being credit constrained, with 59 percent in the top and 80 percent in the bottom asset quartile, varies by wealth group. Households face multiple constraints to accessing credit: 32 percent of sample households are quantity rationed and for 10 percent lack of collateral is the main reason for not accessing semi-formal loans. High levels of transaction cost and risk constraints affect a third of households. Constrained and unconstrained households differ from each other significantly, with the latter reporting higher levels of purchased inputs use and yields, suggesting a link between access to credit and agricultural productivity.

Using full information maximum likelihood for an endogenous switching model allows us to assess the determinants of being credit constrained. Two sets of instrumental variables that will affect a household's credit constraint status but not its crop productivity are used; namely, links to social networks and information access and nonproductive assets, such as consumer durables and livestock. As expected, higher endowments of assets, social capital, and political connections all reduce the likelihood of being credit constrained.

Returns to additional liquidity and endowments are estimated to differ significantly between constrained and nonconstrained households. Liquidity is estimated to increase output for the former but not for the latter. Simulation suggests that eliminating credit rationing could increase yields by 17 percentage points, suggesting that efforts to reduce credit rationing could have significant payoffs. Beyond its impact on agricultural production, credit rationing reduces the scope for nonfarm self-employment testing hypotheses on business start-ups. Being credit constrained is also estimated to significantly reduce the likelihood of nonfarm self-employment by 6.3 percentage points and increase the likelihood of engaging in agricultural wage labor, the lowest-return nonagricultural activity, by about 4 percentage points.

A desire to improve credit access by allowing use of land as collateral has been a key motivation for a large land regularization program supported by Rwanda's government that has made impressive advances thus far. The extent to which this will allow to reduce transaction costs and eliminate supply-side constraints will depend on the ability to link this to a cost-effective registry that is authoritative, up to date, and accessible locally. At the same time, the high incidence of risk rationing in our sample suggests that demand-side considerations will be of equal or even greater importance and that research on the interplay of these two factors will be important.

The paper is structured as follows. Section 2 presents the conceptual framework and sets out the empirical strategy. Section 3 describes the data and provides descriptive statistics. Section 4 discusses the results of the empirical analysis and section 5 concludes.

2. Context and hypotheses

2.1 Conceptual framework

A number of studies have examined the impact of credit rationing on resource allocation in agriculture, crop productivity, and land related investment (for example, Feder et al., 1990; Diagne and Zeller, 2001; Foltz, 2004; Guirkinger and Boucher, 2008). They 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 (Singh et al., 1986; de Janvry et al., 1991). In particular, binding credit constraints translate into a less risky household activity portfolio. Thus, if asset endowments are correlated with the presence of credit constraints, the poor may be excluded from more lucrative activities with higher variances of outcomes that could otherwise help them get out of poverty.

In an ideal world of perfect and complete markets, the recursive property of the model implies that farm households' production and consumption decisions will be separable. Decisions about input use will thus be independent from households' initial resource endowments and output per area unit will be unaffected by the level of liquidity and initial endowments of resources such as land and family labor. However, with market imperfections, households' decisions on production and consumption are simultaneous so that the intensity of input use will be dependent on the availability of capital and initial endowments. Those who, in light of such market imperfections, face binding credit constraints, may well be able to afford only sub-optimal levels of input use that then translate into levels of productivity well below the first-best outcome. This would reduce output per unit of land, income, and ultimately welfare.

Binding credit constraints could lead to a negative relationship between land endowments and productivity as well as a positive impact of households' access to liquidity and their endowment of other resources (for example, family labor) on crop output per unit of land (see Feder et al., 1990; Guirkinger and Boucher, 2008 for a detailed discussion). Still, existing evidence is ambiguous. In Poland, returns to additional capital were very high, though subsidizing credit did not help (Petrick, 2004). In Malawi, access to microfinance did not have a significant effect on net crop income (Diagne and Zeller, 2001). Elimination of credit constraints in Peru is estimated to potentially increase output by between 15% and 32% (Guirkinger and Boucher, 2008). In Tunisia, credit constraints affect profitability and technology adoption by young 'middle class' farmers (Foltz, 2004). In Ethiopia, effects of credit rationing differ across regions (Ali and Deininger, 2012).

While all of these studies examined impacts of credit constraints on agricultural production, they are likely to also affect income diversification into high return off-farm activities which have been shown to

be a critical avenue out of poverty by a large number of studies (Barrett et al., 2001). The reason is that starting up off-farm self-employment generally requires an initial investment. In the absence of savings or other assets to draw upon, this avenue out of poverty may well remain out of reach for asset-poor households. In fact, credit-market related barriers to participation in higher return activities have been identified as highly relevant in many empirical studies (Woldenhanna and Oskam, 2001; Dercon, 1998; Dercon and Krishnan, 1996; Reardon et al., 2000; Eswaran and Kotwal, 1990).

Defining and measuring whether or to what extent a household is credit constrained is in practice often a challenge. Early empirical investigations of the impact of credit rationing focus primarily on the impact of supply side ('involuntary') restrictions on potential borrowers' credit access. Credit market restrictions commonly subsumed under the term quantity rationing may result from policy-induced interest rate restrictions (McKinnon, 1973; Shaw, 1973), lenders' inability to increase interest rates to clear excess demand for loanable funds in an environment characterized by asymmetries in information and enforcement problems (Stiglitz and Weiss, 1981; Bell, 1988),[1] or borrowers' failure to meet collateral requirements (Guirkinger and Boucher, 2008; Boucher et al., 2009). More recent studies considered other forms of credit market rationing induced by factors that drive a wedge between effective and contracted interest rates. These include rationing due to high transaction costs in obtaining credit (including the cost related to preparing loan applications, evaluating collateral value and project viability, and monitoring credit use and repayment) or borrowers' wanting to avoid the risk of losing collateral, for example, due to unfavorable shocks (Carter 1988; Barham et al. 1996; Boucher et al. 2008; Guirkinger and Boucher 2008; Boucher et al. 2009). Unlike quantity rationed households, transaction-cost and risk-rationed households may voluntarily avoid participation in credit markets even if they have projects that would be feasible at rates in a competitive loan market. Below, we consider quantity, transaction costs and risk rationed households all as being credit constrained although we provide estimates for individual types of rationing as well.

Linking these concepts to empirical evidence and determining households who are voluntarily or involuntarily rationed presents its own challenges. The literature has focused on two approaches, namely indirect inference and survey based direct elicitation. We follow the later and refer to the literature for a discussion of the indirect approach that relies on the life-cycle/permanent income hypothesis.[2]

[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).

[2] The indirect approach is based on the sensitivity of consumption to transitory income shocks as indicated by the life-cycle/permanent income hypothesis (for an excellent review of this approach vis-à-vis the direct elicitation approach see Diagne et al. (2000). The theory predicts that consumption is just a function of permanent income (but not its transitory component) in the absence of liquidity and borrowing constraints.

The direct elicitation approach exploits a series of information on credit market participation status of households that includes their borrowing needs, experience and overall perceptions (Feder et al., 1990; Jappelli, 1990; Barham et al., 1996; Boucher et al., 2009). First, it distinguishes applicants from non-applicants in the credit markets by directly asking them whether they applied for loans or not within a given reference period of time. Non-applicants are then asked to specify the reasons for not applying for loans and the response is used to identify credit constrained and unconstrained households. Those who expressed no interest in additional funds because they have sufficient own resources are classified as unconstrained while the rest are categorized as quantity, transaction costs or risk rationed depending on the nature of their response.

Applicants are also further classified in accordance with the outcome of their loan request and follow-up perception questions on whether they wanted to borrow more given the loan terms and if they did not then the reasons why they did not do so. Those applicants who received the full amount they requested and did not want to borrow more are classified as unconstrained in the credit markets. On the other hand, partially or fully rejected applicants are considered to be quantity rationed, and those who expressed interest in additional funds given the loan terms are categorized as quantity, transaction costs or risk rationed based on the reasons they provided for not applying for more funds. This study closely follows this approach, and the specific questions asked and the possible responses used to group households based on their credit market participation status are discussed in detail in the data section.

2.2 Empirical strategy

We estimate an endogenous switching regression model (Lokshin and Sajaia, 2004) to test the relationship between credit constraints and agricultural productivity as well as the likelihood of being constrained in the semi-formal credit market. In this model, the switching equation sorts households into two groups, based on their credit constraint status. The selection and outcome equations that are estimated simultaneously are given as:

$$c_i^* = \delta' X_i + \theta' W_i + u_i \tag{1}$$

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

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

where $\boldsymbol{c_i}$***** is a latent variable that determines the probability that household *i* is constrained in the semi-formal credit sector. $\boldsymbol{c_i}$, is equal to zero if the household is unconstrained (its demand for credit exceeds

the supply of credit, hence $c_i^* > 0$) and takes the value of one if the household is constrained. The dependent variable, y_i, is observed for households in each group where y_{0i} is for unconstrained households and y_{1i} is for constrained households. By definition y_{0i} and y_{1i} are never observed simultaneously for a given household i. X_i is a vector of household characteristics that would influence both y_i and c_i^*. Z_i is a vector of characteristics that explain y_i only and they are not expected to influence regime selection (being constrained or unconstrained). W_i is a vector of identifying instruments on the selection equation (1). The instruments do not have a direct impact on the dependent variable other than through selection in one or the other group. δ, θ, β, and γ are vectors of parameters to be estimated while u_i, ε_{0i} and ε_{1i} are the error terms assumed to be jointly normally distributed.

As some unobserved characteristics that affect the probability of being credit constrained could also affect the outcome variable, the error terms of the selection and the outcome equation may be correlated. Neglect of this could bias the estimated parameters. To address this issue of endogenous switching, we estimate the parameters simultaneously using the Full Information Maximum Likelihood (FIML) method.[3] While previous studies estimate each equation separately (Carter, 1989; Feder et al., 1990; Carter and Olinto, 2003; Petrick, 2004; Guirkinger and Boucher, 2008), the FIML method estimates both selection and outcome equations simultaneously, generating consistent standard errors (Lokshin and Sajaia, 2004). Both Wooldridge (2010) and Greene (2008) characterize the FIML as generally the most efficient estimation strategy to estimate models with endogenous switching providing there are no specification errors.

3. Data and descriptive statistics

3.1 Data

Ways to increase agricultural productivity and diversify income sources are particularly relevant for Rwanda, the most densely populated African country, in light of the fact that subsistence agriculture still contributes 36 percent of GDP, employs 80 percent of the population, and accounts for 45 percent of exports (World Bank, 2011). Our empirical analysis is based on a large nationally representative survey conducted by the World Bank in early 2011.[4] Sampled enumeration areas (EAs) were drawn from a complete list of EAs provided by the National Institute of Statistics of Rwanda (NISR) and a three-stage stratified sampling strategy was followed: First, 100 sectors (4 in each of the country's 25 districts) were randomly selected. Three EAs were then drawn from each sampled sector. Finally, a cluster of 12

[3] We use the movestay STATA command that implements the maximum likelihood method to estimate the endogenous switching regression model (Lokshin and Sajaia, 2004). It allows to simultaneously fit binary and continuous parts to yield consistent standard errors.

[4] The data is from the first round survey for the impact evaluation of the Government of Rwanda's Land Tenure Regularization Program.The study population excludes areas where, at the time of data collection, the project had already started. As a result, Kigali Province, Kirehe district in Eastern Province and Rubavu district in Western Province as well as sectors (about 20% of the total) where program implementation had already been started by September 2010 were dropped to avoid potential contamination.

households were randomly selected from each EA, for a total sample size of 3,600 households. Figure 1 illustrates the geographical location of sample cells.

The survey includes detailed information on demographics, resource endowments, social networks, crop production and agricultural practices, households' perceptions and participation in key markets including those for credit, land and other inputs. The agricultural module covers the first cropping season in 2010 (March to August).[5] Information on loan applications in the past 12 months and respondents' decisions on credit market participation is used to classify households into being constrained or unconstrained in informal, semi-formal and formal credit markets following the direct elicitation approach.[6] Figure 2 illustrates the procedure followed to do so: First, those who did not apply for a loan in the past 12 months were asked why they did not request for a loan from each source. Households who reported having sufficient resources of their own or being price rationed due to high interest rates were classified as unconstrained. Constrained households fall into three categories, namely (i) risk rationed ones who reported fear of being indebted and possible loss of collateral; (ii) quantity rationed ones who lacked collateral and feared being rejected; and (iii) transaction cost constrained ones who failed to borrow due to a lack of supply in the community and lack of knowledge on how and where to apply for a loan.

Observations were aggregated for all sources in each sector (formal, semi-formal and informal), allowing for multiple types of constraints in each sector per household. However, if households reported that they did not apply because they had enough resources in any of the sources in a particular sector, they were subsequently classified as unconstrained. Second, loan applicants were further classified based on the status of their loan application: applicants whose demand was fully met (unconstrained), applicants whose request was partially or fully rejected (quantity rationed), and applicants who received the full loan amount they requested for but still would have liked to borrow more given the loan terms (constrained, and then subsequently classified based on their stated reason for not applying for more in a similar fashion to those of non-applicants).

3.2 Descriptive evidence

Table 1 presents data on households' participation in credit markets by asset wealth quartiles.[7] Results point towards a rather inactive formal credit market, in line with the results from the Finscope Rwanda

[5] While levels of total crop output are similar between season A and B for most crops, there are some differences for sorghum and paddy as well as coffee and fruits (see NISR 2008 for details) but these do not affect our results.

[6] The informal sector sources include friends or neighbors, family relatives and private money lender. Sources of credit in the semi-formal sector were divided between associations, agricultural input suppliers Roscas, microfinance institutions and NGOs (including faith based). The credit module was intentionally administered to the female respondent (if any) in the household, to avoid responses based on the perceptions of the male respondent only. As a result, 82 percent of the constraint variables are based on female responses.

[7] Wealth quartiles are computed using a principal component analysis to generate wealth indexes following Filmer and Pritchett (2001). Components include: total size of land owned, whether the household owns the dwelling or not, number of buildings on the plot, binary variables for different types of roofing, exterior wall and flooring materials as well as main source of drinking water and lighting, and number of household asset items (mattress, table, sewing machine, refrigerator, radio, radio cassette, bicycle, motorcycle and mobile phone owned) and livestock

2008 survey.[8] Indeed, only 3 percent of the sampled households applied for a bank loan during the 12 months period preceding the survey. Such limited formal credit market activity is not uncommon in rural areas of developing countries due to limited outreach of the formal system. To access extra liquidity rural households are then restricted to borrowing in the informal and the semi-formal sectors. Credit market activity in the study villages are almost equally divided between the informal and the semi-formal sectors with about a fifth of households participating in each sector. Amounts borrowed in the semi-formal sector are relatively larger (USD 55 on average versus USD 34 in the informal sector), but interest rates are high at the same time.[9] Despite no clear differences in participation being observed, the amount of loan requested and approved is positively correlated with the asset index measure in both the informal and semi-formal credit markets. Conditional on participation, asset rich households are borrowing relatively more than their asset poor counterparts.

The main purposes for taking loans from the informal sector are consumption (35 percent), investment (26 percent), health (25 percent) and education (12 percent).[10] Almost 60 percent of loans from family, friends and neighbors are thus used to smooth consumption in response to external shocks. Loan amounts in the informal sector are relatively small and mainly used for purposes other than investment. As this implies that they are of limited relevance for policy, we focus on credit from the semi-formal sector. Such credit is more frequently used for investment (37 percent), followed by consumption (33 percent) and less frequently for health (14 percent) and education (12 percent). Only 29 percent of the lowest asset quartile group use loans to invest (whether to purchase land, agricultural inputs or to start a business), while over 40 percent of the relatively asset rich households take out loans for these purposes.

Table 2 presents evidence on the magnitude and nature of credit rationing in formal, semi-formal and informal credit markets. Note that the data enable us to capture multiple constraints per source of credit for both the semi-formal and the informal sectors.[11] Almost all households in the sample reported being credit constrained in the formal sector, making further analysis for this sector difficult. In the semi-formal sector, 71 percent are classified as being credit constrained with a clear differences by wealth (82 percent in the lowest asset index quartile versus 59 percent in the highest quartile). The most recurring constraints faced by households in securing a loan from semi-formal institutions are related to high transaction costs

(bulls/oxen, heifer/cows, calves, sheep, goats, pigs, donkeys, mules/horses, rabbits, chicken, fish, beehives) owned by the households. Results are not reported, but available upon request from the authors.

[8] Finscope Rwanda 2008 reports that 21percent of the surveyed households utilized formal financial products, with only 14% using formal bank products. These slightly higher numbers can likely be attributed to the exclusively rural character of our survey while 15 percent of the 2,000 households composing the Finscope sample resided in urban areas.

[9] The low interest rates observed in the informal sector can be explained by the relative absence of moneylenders in Rwanda.

[10] Consumption purposes include food and non-food consumption, housing, buying vehicle and financing ceremonies; investment purposes include the purchase of land, agricultural inputs, livestock or to start a business.

[11] Indeed, reasons for not borrowing in those sectors were further disaggregated by sub-sources within the semi-formal and informal sectors.

(62 percent of the total sample and 90 percent of constrained households).[12] The absence of suppliers, potentially due high transportation costs to reach remote areas and the absence of a viable client base, and the lack of knowledge on modalities to access semi-formal finance appear widespread in rural Rwanda and justify the need for interventions targeting geographical outreach and financial literacy.

Relatively asset-rich households face lower transactions cost constraints, potentially because of higher level of access to information and larger social networks (see Appendix Table 1). A third of sampled households are quantity-rationed with 10 percent of our sample reporting lack of collateral as the main reason for not applying at all or for not asking for more given the loan terms and conditions. A nonnegligible 21 percent of households are risk rationed in the semi-formal credit sector suggesting additional imperfections in the insurance market. We observe a significantly lower proportion of risk rationed households among the poorest quartile as compared to the other quartiles. This contradicts the notion of decreasing absolute risk aversion maintained in much of the literature. The difference could be partially explained by the fact that as households get richer, the most immediate constraints in accessing credit may be removed and hence risk aversion emerges as a key reason for not taking up loans. Although data collected in a disaggregated manner by different sources of semi-formal credit can be attractive, it at the same time poses serious limits to clearly identify explanations for the differences observed across groups. There is some overlap, with 7 percent of households classified as both quantity and risk rationed. Interestingly, in the informal credit sector where levels of rationing are relatively lower, though still high (58 percent), risk rationing seems uncorrelated to wealth.

Household characteristics, asset endowments, social capital, and agricultural input use intensity by credit constrained status in informal and semi-formal sectors are presented in Table 3.[13] Asset poor, less socially connected as well as female-headed households appear to be more likely to be constrained in semi-formal credit markets. The impact of accessing credit on agricultural productivity should be driven by higher input use as households can rely on extra resource and liquidity to invest on their land. As anticipated, there are systematic differences in use and intensity of selected inputs between households who are credit constrained and unconstrained. On average, 24 percent of unconstrained households use chemical fertilizer while only 14 percent of rationed households do so. The same pattern emerges for use of organic fertilizer as 80 percent of unconstrained vs. 70 percent of constrained households use manure. The use of improved seeds (30 percent versus 26) and extension advice (26 percent versus 17) are also higher for

[12] Households reporting not being a member of the semi-formal lending institution (90 percent of transaction cost constrained household), not knowing how and where do apply (64 percent), a lack of supplier (21 percent), or/and not having a bank account (8 percent) are classified as transaction costs constrained (see Figure 2). Note that the percentages do not necessarily add up to 100 percent as per the design of the questionnaire. Households were asked to report the main reason for being rationed from each of the mutually exclusive sources of credit in the semi-formal sector, thereby potentially resulting in multiple responses in the types of transaction costs per household. Data are available upon request from the authors.

[13] As the analysis exclusively focuses on the impact of credit constraint in the semi-formal sector, there is no further discussion on the informal sector. The figures are reported for informational purposes only.

unconstrained households. Although constrained households seem to use more family labor (particularly in terms male family labor), unconstrained households resort more often, on average, to the use of hired labor (56 percent versus 38 percent). Overall, there is no statistically significance difference in terms of total labor days per hectare of cultivated land. Descriptive statistics given in Table 4 on the use of inputs by farm size points towards potential labor market imperfections: labor intensity is inversely related to farm size as those in the first tercile of the holding size distribution use three times more labor per hectare than those in the third. The same pattern is observed for the quantity of fertilizers and pesticides used per hectare. Both provide hints in explaining the negative relationship between land size and productivity, irrespective of credit access, found in the empirical analysis.

In addition, it is also of interest to note that, while almost all rural households are involved in agriculture, a third of the sample engages in agricultural wage labor and a fifth in nonfarm employment or have their own nonagricultural business. At a descriptive level, and consistent with the notion that credit can support the initial investment needed to start up a nonfarm business, constrained households are more likely to rely on wage labor (38 percent for constrained vs. 27 percent for unconstrained ones) whereas unconstrained ones are more likely to rely on high-return income sources: 24 percent vs. 18 percent are involved in off-farm wage labor and 31 percent of unconstrained vs. 20 percent of constrained households involved in self-employment. Although one should be careful not to interpret too much into such figures given that they come from a very small sample, even for the group engaging in higher return activities, incomes from nonfarm activities are more than double for unconstrained than constrained households.

4. Econometric results

4.1 Specification and variable choice

We use the Full Information Maximum Likelihood (FIML) method to estimate the parameters of the endogenous switching regression model of the system of equations (1-3) for semi-formal credit markets. The dependent variable in the regression estimates is the logarithm of the value of crop output per hectare. The selection indicator is defined as whether the household is constrained (1) or not (0) in the semi-formal credit sector. Table 5 provides the main results. Columns 1-3 report the results when the selection variable is defined as quantity rationed only while columns 4-6 correspond to a selection variable more broadly defined by including all types of rationing (quantity, transaction costs and risk rationed). All regressions include district dummies and standard errors are clustered at village level. The likelihood test of the independence of the error terms in the two equations is rejected in both cases, supporting the validity of the endogenous sample separation and the use of the FIML estimation strategy.

The selection equation includes explanatory variables from the productivity regression as well as assets and links to social networks and information access as two sets of instrumental variables that will affect a household's credit status but not its crop productivity. The first set of variables includes the value of non-productive household assets and livestock owned by the household.[14] As noted earlier, wealthier households are less likely to face a binding credit constraint as they might either have sufficient own resources or face less difficulty in securing loans if in need.

Access to social networks and information is likely to help access semi-formal credit as such loans are often channeled through local institutions. Measures of access to social networks include (i) if the household head was born in the village; (ii) if s/he had been displaced during the war; (iii) the number of adult children with their own households in the village; (iv) if head or spouse (or a blood relative) hold or held political office.[15] A binary variable whether the head or spouse listen to news on the radio at least once a week is also used as a proxy for information access.

4.2 Determinants and impacts of credit rationing

Results for the selection equation in columns 3 and 6 of Table 5 support the hypothesis of asset ownership and access to information or political networks reducing the likelihood of being rationed in the semi-formal sector significantly. Key determinants include livestock (rather than household asset) ownership, having a household member or relative holding political office, and listening to news at least once a week. The magnitude of the coefficients is similar between quantity- and overall- rationing. Of the factors affecting both production and selection, education is estimated to reduce the incidence of all types of credit rationing while effects of cooperative membership and household composition are more heterogeneous.

Concerning impacts, we first discuss quantity rationing (columns 1 and 2). Consistent with predictions of the household model, the results suggest that access to liquidity or family labor endowments do not affect output for households who are not credit unconstrained in semi-formal markets but significantly reduce the value of agricultural production for credit constrained ones. For households who are quantity constrained, an exogenous increase in credit of US$ 100 would increase output value by 8.9 percentage points. Similarly, an additional male household member is estimated to increase output at the margin by 9%, suggesting that constrained households are unable to muster the resources to hire labor up to the optimum. The size of the households' land endowment is estimated to negatively affect output per hectare for both those who are credit constrained and those who are not (though with a slightly larger coefficient

[14] As animal traction is not used for crop production in Rwanda, livestock holdings will not directly affect productivity.The largest value of livestock comes from cows, which are not traditionally used as a source of draught power in Rwanda. In addition, the amount of manure used per hectare and the value of livestock are not correlated, suggesting that manure is either bought (animal) or comes from compost of crop residue.

[15] Offices include 'ten households representatives' (nyumba kumi), village committee, cell executive committee, sector council and/or in the traditional local justice court (abunzi)

for the former), possible due to other market imperfections (such as labor market imperfection at household and community levels) that might prevent households from using their land endowment optimally.

We obtain similar results when all types of credit constraints are considered (columns 4-6 of Table 5). Male family labor does have a positive and significant effect on crop productivity only when the credit constraint is binding. It is highly likely that unconstrained households could use hired labor to compensate for any shortage in family labor as shown in the descriptive statistics. On the other hand, constrained households will find it difficult to adjust through participation in the labor market as they may lack the necessary resources to do so. The negative relationship between land size and the value of output per hectare remains robust irrespective of the definition of being credit constrained in the semi-formal sector. The negative relationship between land size and agricultural productivity is consistent with evidence based on Rwandan data from 1990 by Byiringiro and Reardon (1996). While imperfections in land, labor or other input markets could explain it, descriptive statistics suggest that the intensity of labor and other inputs decreases significantly with land size.[16] This suggests that having access to credit markets offsets only part of the effects of imperfection in the other markets.

To check the robustness of our results, we estimate two other specifications. First, we define households as credit constrained if they have no option to borrow in both informal and semi-formal credit sectors. Secondly, we use the logarithm of household land endowment instead of a simple linear specification. Results, presented in Table 6, are consistent with earlier findings both in terms of the estimation strategy and the avenues through which credit constraints affect economic outcomes.

To quantify efficiency losses arising from binding credit constraints in the semi-formal sector, we use the results from columns 4-6 in Table 5 and, following the standard literature on treatment effects, define the potential impact of exogenously removing binding constraints in the semi-formal credit sector as follows

$$\hat{\Delta} y_i = (\hat{\beta}_0 - \hat{\beta}_1)' X_i + (\hat{\gamma}_0 - \hat{\gamma}_1)' Z_i. \tag{4}$$

Using the broader definition of being credit constrained that includes quantity constraints but also risk and transaction costs, we estimate that removing the constraint will result in an increase of households' total value of output from USD 272 to USD 326 (or by 17 percentage points).[17] This predicted effect is large and could potentially be explained by the large scope for more intensive use of inputs including labor by

[16] Refer to Ali and Deininger (2012) for a detailed study of the negative relationship between land and productivity using the same data. Analysis points towards the translation of labor market imperfections into low labor opportunity cost for small farm holders.

[17] Note that using the prediction of the model when the definition of constraints only accounts for quantity constrained households, we estimate a threefold increase in yield per ha. The difference between the two estimations can potentially be the result of systematic differences between quantity rationed households and other types of rationing. In addition, the selection regime considering quantity rationed households only relies on the assumption that these households do not face any other demand side binding constraints (risk aversion or transaction costs).

Rwanda's poorest farmers. Yet, while supply- and demand-side interventions to ease access to agricultural finance in Rwanda could potentially have large positive impact on crop production, the effect could be dampened if households face additional market imperfections such as inadequate input supply or distortions in the labor market.

4.3 Determinants of activity choice

As most households in rural Rwanda do not specialize in one activity only, we use a multivariate probit[18] specification with participation in nonfarm self-employment, farm wage labor, and nonfarm wage labor as dependent variable, to estimate determinants of activity choice. Independent variables include head's characteristics, assets, non-labor income, access to credit, credit rationing, and locational characteristics. The results are given in table 7. Everything else constant, being credit constrained is estimated to significantly reduce the likelihood of nonfarm self-employment by 6.3 percentage points while increasing the likelihood of engaging in agricultural wage labor, the lowest-return activity considered, by 4 percentage points.[19] Participation in nonagricultural labor markets is estimated to be unaffected by credit constraints, in line with the notion that education is more important for such employment than credit. Thus, beyond its impact on agricultural production, credit rationing reduces the scope for nonfarm self-employment. Detailed data to test hypotheses regarding the underlying mechanisms for business start-ups could be of great interest.

Although our survey does not allow us to do so, it reveals a number of regularities. Endowments with land or livestock reduce the likelihood of participating in wage labor but land ownership increases the likelihood of participating in nonfarm self-employment even beyond its impact on credit rationing, similar to what emerges for other durable assets. Location also matters with those close to a market are more likely to participate in nonfarm self-employment. Female-headed households are less likely to participate in both nonfarm self-employment and wage labor. Education is estimated to increase self-employment to some extent but affects participation in nonfarm wage labor in a quadratic form. While members of larger households are also more likely to participate in both types of wage employment, no significant relationships are observed with the likelihood of participating in nonfarm self-employment.

5. Conclusion and policy implications

Based on an improved estimation technique and the use of nationally representative data, this paper finds that credit rationing in Rwanda is widespread and that it affects the efficiency of agricultural production as well as the likelihood of participating in higher-return nonfarm economic activities. The magnitudes

[18] We use the mvprobit STATA command that estimates multiple equations probit model using the method of maximum simulated likelihood (Cappellari and Jenkins 2003).

[19] The marginal effects are computed by taking the difference in the marginal predicted probabilities of success with a change from being unconstrained to constrained in the semi-formal sector.

involved are by no means trivial—exogenously lifting constraints to credit access could increase yields by at least 17 percent according to our estimates—and further exploration of the mechanisms for nonfarm participation in the context of overall structural transformation would be of interest.

A key policy that has traditionally been advocated to address credit constraints relates to formal and semi-formal lenders' ability to identify and transfer land at low cost so as to reduce the cost of using it as collateral for loans. Rwanda is one of the few countries in Africa to have undertaken a large program of systematic land tenure regularization that aims to deliver titles for all the 10 to 11 million land parcels in the country by 2013.[20] In theory, formalizing land rights can affect investment demand due to farmers' higher tenure security and credit supply due to a collateral effect (Feder and Nishio, 1999). While such effects have been rather elusive in Africa (Migot-Adhola et al., 1991; Place and Migot-Adholla, 1998), high levels of population density as well as land market activity in Rwanda, as well as higher global demand for agricultural commodities, imply that it will be of great interest to see whether this program will affect credit markets. At the same time, many studies from developing countries show that risk may be a more relevant constraint to investment (Karlan et al., 2012), consistent with the high incidence of risk rationing in our sample. Further study to explore not only the mechanisms through which credit constraints affect participation in nonagricultural self-employment but also the extent to which risk-related concerns may attenuate the impacts of supply-side factors will be of great interest not only for Rwanda but also for other African countries.

[20]The Land Tenure regularization Project and Rwanda's context is explained in details in Ali et al. (2012). DFID annual review provides the most updated data on the advancement of the project. http://projects.dfid.gov.uk/project.aspx?Project=200284

Figure 1: Map of sampled cells (total 3,600 households), source: World Bank survey 2011

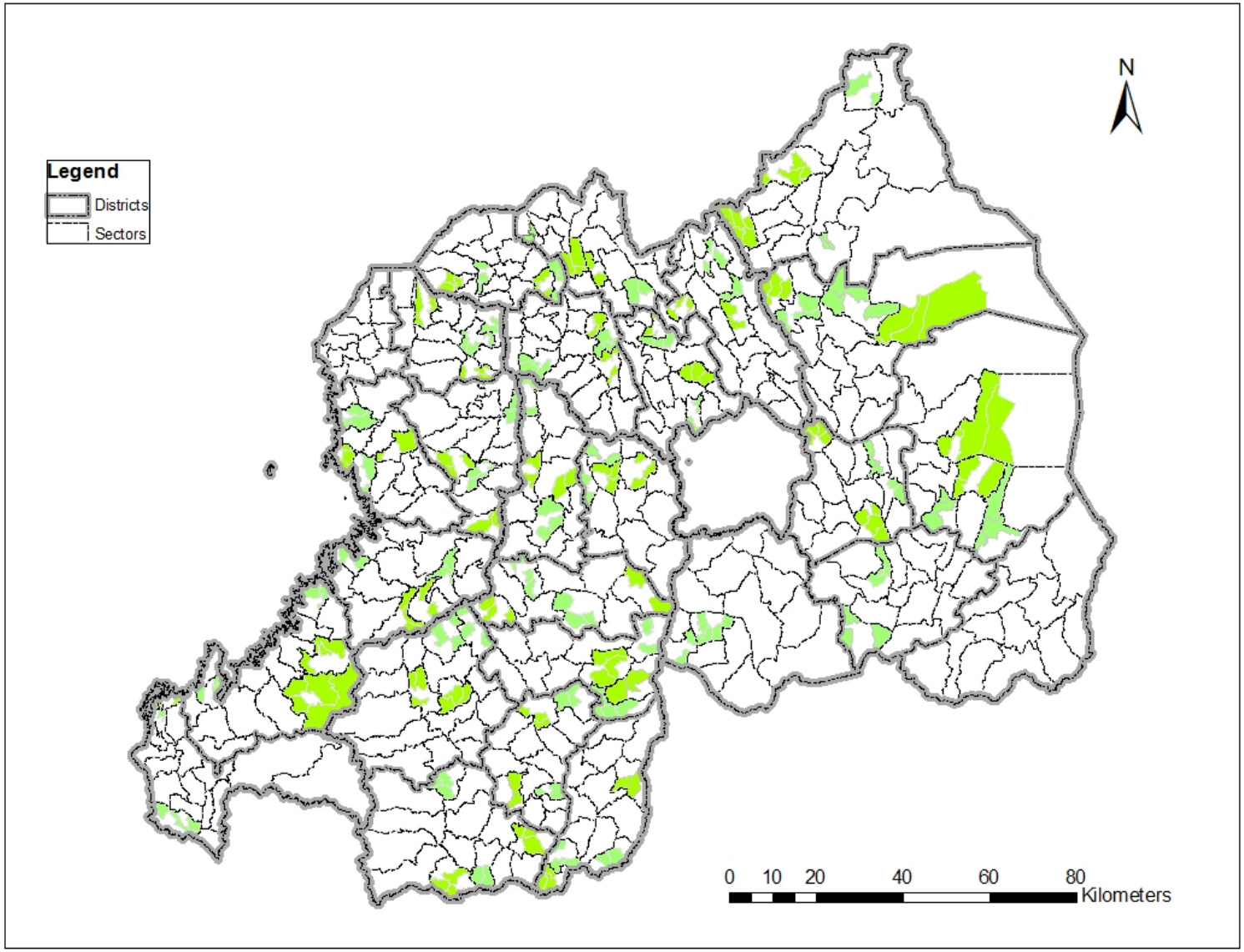

Figure 2: The direct elicitation approach, source: World Bank survey 2011

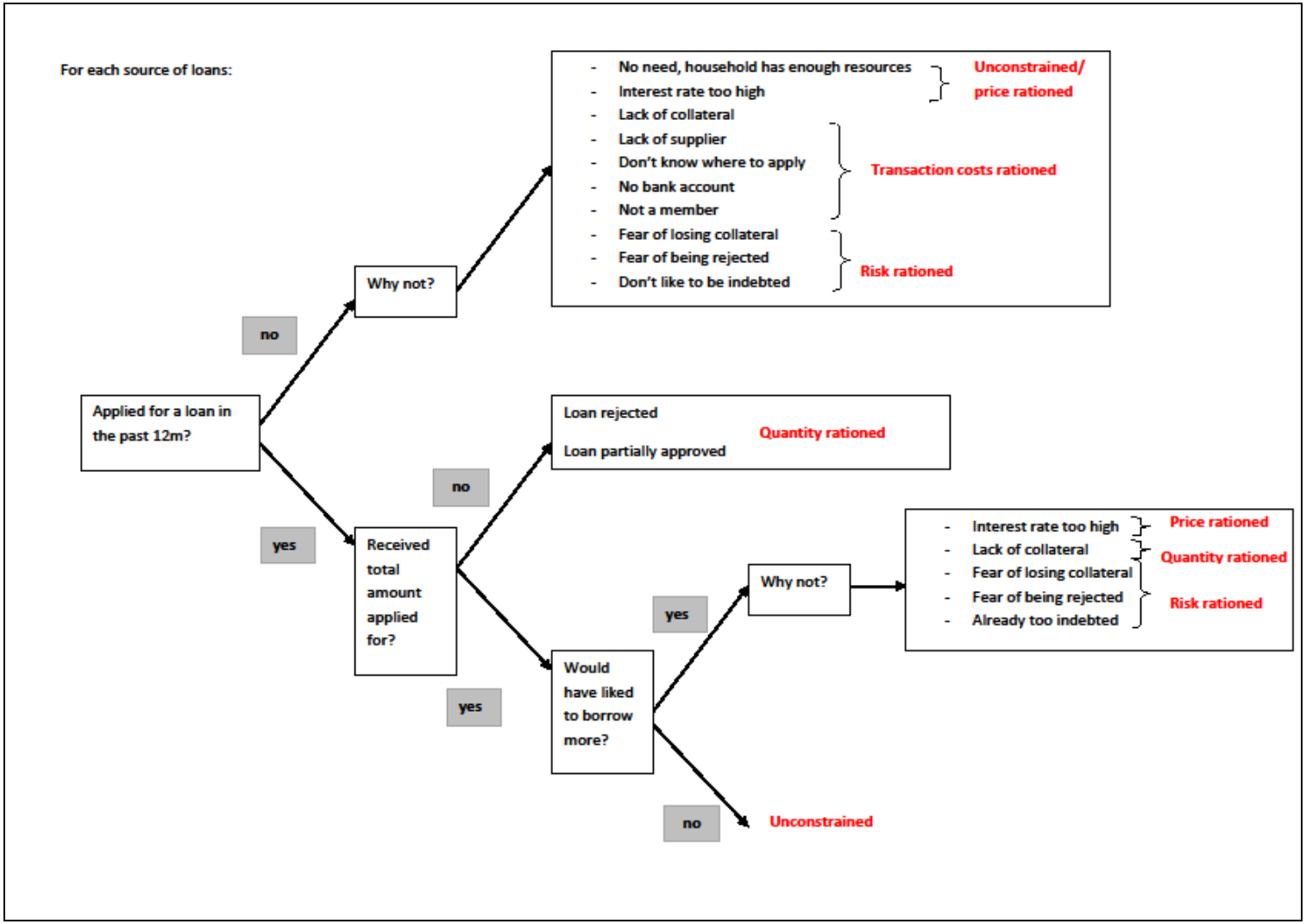

Table 1: Descriptive evidence on credit access

	Total	By wealth quartile						
		1	2		3		4	
Formal sector								
Applied for a loan	0.03	0.01	0.01		0.02		0.06	
Amount applied for, in USD	606	87	96		192	*	851	
Loan fully approved	0.93	0.86	1.00		1.00		0.90	
Loan partially approved	0.02	0.14	0.00		0.00		0.02	
Amount received, in USD	422	83	96		200	*	501	
Monthly interest rate	0.02	0.01	0.03	*	0.02		0.02	
Loan length, months	12	9	7		9		14	*
No guarantee	0.12	0.29	0.11		0.16		0.07	
Land as a collateral	0.50	0.71	0.78		0.58		0.42	
Loan purpose								
Investment	0.47	0.50	0.78		0.47		0.42	
Consumption	0.27	0.00	0.22		0.26		0.29	
Heath	0.09	0.29	0.00	*	0.11		0.06	
Education	0.10	0.14	0.00		0.16		0.11	
Semi-formal sector								
Applied for a loan	0.20	0.17	0.22	***	0.23		0.21	
Amount applied for, in USD	55	28	28		57	***	102	***
Loan fully approved	0.98	1.00	0.98		0.98		0.96	
Loan partially approved	0.01	0.00	0.01		0.02		0.01	
Amount received, in USD	51	27	26		54	***	93	***
Monthly interest rate	0.06	0.06	0.07		0.05	*	0.05	
Loan length, months	5	5	5		5		5	
No guarantee	0.62	0.67	0.66		0.62		0.51	**
Land as a collateral	0.31	0.31	0.29		0.29		0.37	*
Loan purpose								
Investment	0.37	0.29	0.36		0.44		0.41	
Consumption	0.33	0.38	0.37		0.31		0.27	
Heath	0.14	0.18	0.16		0.14		0.09	
Education	0.12	0.10	0.09		0.08		0.20	***
Informal sector								
Applied for a loan	0.21	0.20	0.20		0.23	*	0.19	*
Amount applied for, in USD	34	13	24	***	33	**	68	***
Loan fully approved	0.99	0.98	0.99		1.00		1.00	
Loan partially approved	0.00	0.00	0.00		0.01		0.00	
Amount received, in USD	34	14	24	***	33	**	69	***
Monthly interest rate	0.01	0.01	0.01		0.01		0.02	
Loan length, months	4	4	4		4		4	
No guarantee	0.97	0.98	0.95		0.96		0.96	
Land as a collateral	0.03	0.02	0.03		0.04		0.02	
Loan purpose								
Investment	0.25	0.14	0.23	**	0.30		0.31	
Consumption	0.35	0.40	0.37		0.30		0.30	
Heath	0.25	0.32	0.27		0.24		0.20	
Education	0.12	0.12	0.10		0.11		0.16	
Total Observations	3294	823	824		823		824	

Source: Own computation from WB survey 2011.

Note: The wealth quartiles are calculated using a principal component analysis based on housing conditions, assets, livestock and land ownership. T-test is performed using the immediate lower quartile as a reference: * significant at 10%; ** significant at 5%; *** significant at 1%

Table 2: Evidence of credit constraints in formal, semiformal, and informal sectors

	Total	By wealth quartile						
		Q1	Q2		Q3		Q4	
Formal sector								
Constrained	0.87	0.96	0.93	***	0.88	***	0.74	***
Quantity rationed	0.09	0.08	0.10		0.08		0.09	
Lack of collateral	0.06	0.06	0.07		0.05		0.05	
Risk rationed	0.07	0.03	0.04		0.06	*	0.14	***
Transaction costs rationed	0.69	0.82	0.76	***	0.70	***	0.49	***
Semi-formal sector								
Constrained	0.71	0.82	0.76	***	0.65	***	0.59	**
Quantity rationed	0.32	0.38	0.38		0.28	***	0.25	*
Lack of collateral	0.10	0.13	0.12		0.08	***	0.06	
Risk rationed	0.21	0.13	0.23	***	0.22		0.24	
Transaction costs rationed	0.62	0.71	0.67	*	0.58	***	0.52	**
Quantity and risk rationed	0.07	0.03	0.10	***	0.07	*	0.08	
Informal sector								
Constrained	0.58	0.74	0.63	***	0.52	***	0.42	***
Quantity rationed	0.36	0.52	0.42	***	0.31	***	0.21	***
Lack of collateral	0.05	0.09	0.07	*	0.04	**	0.03	
Risk rationed	0.24	0.22	0.25		0.25		0.23	
Transaction costs rationed	0.28	0.38	0.31	***	0.24	***	0.18	***
Quantity and risk rationed	0.09	0.11	0.11		0.09		0.06	**
Total Observations	3294	823	824		823		824	

Source: Own computation from WB survey 2011.
Note: The wealth quartiles are calculated using a principal component analysis based on housing conditions, assets, livestock and land ownership. T-test is performed using as a reference the immediate lower quartile: * significant at 10%; ** significant at 5%; *** significant at 1%

Table 3: Descriptive statistics at the household level, by credit constrained status

	Total	Constrained in informal sector			Constrained in semi-formal sector		
		Yes	No		Yes	No	
Household characteristics							
Female headed hhd=1	0.28	0.34	0.21	***	0.32	0.20	***
Number of children (0-14)	2.09	1.95	2.27	***	1.99	2.31	***
No. female adults	1.31	1.28	1.35	**	1.29	1.37	***
No. male adults	1.10	1.02	1.22	***	1.06	1.19	***
Age head	46.32	48.45	43.42	***	47.31	43.95	***
No. years of schooling head	3.21	2.76	3.83	***	2.89	4.00	***
Asset endowments							
Total land owned	0.65	0.53	0.81	***	0.55	0.88	***
% of high quality soil	0.36	0.35	0.38	**	0.36	0.37	
% of medium quality soil	0.15	0.14	0.15		0.15	0.15	
% of wetland	0.07	0.07	0.07		0.07	0.08	
% of irrigated land	0.05	0.05	0.04	*	0.05	0.04	
Total borrowed, USD	23	15	33	***	15	41	***
Sale value of hhd assets, USD	56	36	83	***	43	87	***
Sale value of livestock, USD	163	124	217	***	139	222	***
Social capital							
No. of adult children in village	0.36	0.44	0.24	***	0.38	0.32	*
Hd born in the village	0.71	0.69	0.73	***	0.69	0.75	***
Hd displaced	0.47	0.47	0.47		0.46	0.49	*
Member of farm cooperative	0.22	0.20	0.25	***	0.19	0.30	***
Listen to the news at least once a week	0.69	0.62	0.79	***	0.65	0.79	***
Head/Spouse holds political office	0.10	0.08	0.13	***	0.08	0.15	***
Relative holds political office	0.21	0.18	0.24	***	0.18	0.27	***
Distance to the market, min	371	366	377		365	383	
Distance to the road, min	276	279	272		283	261	
Input use and agricultural productivity							
Used chemical fertilizer	0.17	0.14	0.21	***	0.13	0.25	***
Used manure	0.73	0.70	0.77	***	0.70	0.81	***
Used pesticides	0.13	0.11	0.15	***	0.11	0.17	***
Used improved seed	0.26	0.23	0.29	***	0.24	0.30	***
Used extension advice	0.19	0.17	0.22	***	0.16	0.26	***
Male family labor days	136	140	129		143	117	***
Female family labor days	326	363	274	***	333	307	
Used hired labor	0.43	0.36	0.53	***	0.38	0.56	***
Hired labor days	146	139	151		144	148	
Total labor days	488	495	482		493	480	
Yield per ha in USD	444	419	477	***	428	481	**
Income and its sources							
Involved in agriculture	0.97	0.97	0.98		0.97	0.98	
Involved in agricultural wage labor	0.35	0.40	0.28	***	0.38	0.27	***
Total yearly agricultural income, USD	115	116	113		116.	111	
Involved in nonfarm wage labor	0.20	0.18	0.23	***	0.18	0.24	***
Total yearly off-farm income, USD	480	337	629	***	319	780	***
Off-farm self-employment activities	0.23	0.19	0.28	***	0.20	0.31	***
Total yearly profit, USD	649	369	915	*	372	1077	**
Total Observations	3600	2079	1521		2542	1058	

Source: Own computation from WB survey 2011.
Note: * significant at 10%; ** significant at 5%; *** significant at 1%

Table 4: Input intensity by total firm size

	Total	Land size				
		Small	Medium		Large	
Used chemical fertilizer	0.17	0.12	0.15	*	0.21	***
Value of chemical fertilizer used in USD per ha	39	82	30	***	22	
Used manure	0.73	0.66	0.75	***	0.80	***
Manure used in kg per ha	4814	8333	4307	***	2504	***
Used pesticides	0.13	0.09	0.12	**	0.16	***
Value of patricides used in USD per ha	27	69	20	***	8	***
Used improved seed	0.26	0.19	0.25	***	0.31	***
Used extension advice	0.19	0.15	0.20	***	0.21	***
Male family labor days, per ha	136	234	138	***	71	***
Female family labor days, per ha	326	592	291	***	127	***
Used hired labor	0.43	0.26	0.40	***	0.62	***
Hired labor days, per ha	146	71.56	77.33		61.15	
Total labor days, per ha	488	948	537	***	276	***
Total Observations	3493	1124	1185		1184	

Source: Own computation from WB survey 2011.

Note: T-test is performed using as a reference the immediate lower tercile for land size: * significant at 10%; ** significant at 5%; *** significant at 1%

Table 5: Determinants of credit constraints and their impact on productivity

	Quantity constrained only			All constraints		
	Unconstr.	**Constr.**	**Selection**	**Unconstr.**	**Constr.**	**Selection**
Total borrowed, USD1000	0.028	0.885***		0.035	0.644**	
	(0.149)	(3.461)		(0.190)	(2.329)	
Total land owned, in ha.	-0.265***	-0.339***	-0.060***	-0.171***	-0.347***	-0.060**
	(-8.354)	(-4.679)	(-2.949)	(-5.197)	(-7.686)	(-2.406)
No. of children (0-14)	0.001	0.042*	-0.002	-0.014	0.021	-0.036*
	(0.073)	(1.835)	(-0.107)	(-0.620)	(1.364)	(-1.888)
No. of female adult	-0.016	-0.044	-0.003	-0.007	-0.030	-0.048
	(-0.691)	(-0.973)	(-0.115)	(-0.175)	(-1.132)	(-1.561)
No. of male adult	0.031	0.090**	0.076**	-0.009	0.052**	0.023
	(1.174)	(2.209)	(2.493)	(-0.243)	(2.132)	(0.752)
Female headed hhd=1	0.061	-0.050	0.048	0.070	-0.023	0.004
	(1.003)	(-0.691)	(0.663)	(0.732)	(-0.488)	(0.052)
Age head	-0.001	-0.002	-0.002	-0.002	0.001	0.005**
	(-0.574)	(-0.646)	(-0.803)	(-0.905)	(0.510)	(2.361)
No. year of schooling of head	0.005	-0.007	-0.027***	0.023	-0.001	-0.040***
	(0.582)	(-0.509)	(-2.859)	(1.645)	(-0.097)	(-3.845)
Member of farm cooperative	0.043	0.066	0.018	-0.002	0.025	-0.299***
	(0.820)	(0.851)	(0.324)	(-0.021)	(0.435)	(-5.002)
Distance to market, min	0.001	-0.000	-0.000	0.001	0.000	0.000
	(1.017)	(-0.273)	(-0.052)	(0.681)	(0.535)	(0.012)
Distance to main road, min	-0.001	-0.001	0.001	-0.000	-0.001**	0.000
	(-0.795)	(-0.742)	(0.958)	(-0.078)	(-2.080)	(0.582)
% of high quality soil	0.298***	0.159*		0.293***	0.249***	
	(4.800)	(1.660)		(2.811)	(3.890)	
% of medium quality soil	0.253***	-0.061		0.240*	0.088	
	(3.018)	(-0.606)		(1.846)	(1.155)	
% of wetland	-0.031	0.188		-0.108	0.088	
	(-0.237)	(0.912)		(-0.567)	(0.663)	
% of irrigated land	-0.066	0.093		-0.228	0.052	
	(-0.593)	(0.519)		(-1.092)	(0.496)	
VPU program in village			-0.035			-0.065
			(-0.558)			(-1.072)
Sale value of hhd assets, in USD1000			-0.444			-0.415
			(-1.310)			(-1.433)
Sale value of livestock, in USD1000			-0.292***			-0.240**
			(-2.701)			(-2.202)
No. adult children in village			-0.033			-0.062*
			(-1.049)			(-1.819)
Hd born in the village=1			-0.019			-0.112
			(-0.331)			(-1.604)
Hd was displaced=1			0.011			0.028
			(0.192)			(0.487)
Listen to the news at least once a week			-0.137**			-0.262***
			(-2.561)			(-4.226)
Head/spouse holds political office			-0.199**			-0.240***
			(-2.517)			(-2.987)
Relatives holds political office			-0.201***			-0.232***
			(-3.399)			(-3.641)
Distance to MFI, min			0.000			0.000
			(0.321)			(0.158)
Constant	6.004***	5.247***	-0.151	5.749***	5.470***	1.301***
	(41.122)	(18.194)	(-0.805)	(16.776)	(38.721)	(7.737)
Sigma	1.082**	0.990**		0.987**	0.985**	
Rho	0.607*	0.281		0.081	0.276*	
Log-Likelihood		-6,142.22			-5,996.69	
Chi2		269.896			175.465	
Chi2_c		33.868			7.282	
Number of observations		3,119			3,119	

Note: Dependent variable is the log of output per ha. The dependent variable of the selection equation is a binary variable whether or not the household is constrained (based on the definition chosen). District dummies not reported. t-stats in parenthesis.
T-test * significant at 10%; ** at 5%; *** at 1% ***. Standard errors clustered at the village level.

Table 6: Impact of credit constraint on productivity: robustness tests

	No option in informal markets			Non linear		
	Unconstr.	**Constr.**	**Selection**	**Unconstr.**	**Constr.**	**Selection**
Total borrowed, USD1000	0.085	0.775***		0.077	0.699***	
	(0.495)	(2.700)		(0.400)	(2.603)	
Land owned, in ha.	-0.224***	-0.412***	-0.042**			
	(-6.834)	(-5.918)	(-2.011)			
Log land owned				-0.382***	-0.356***	-0.070***
				(-10.439)	(-17.431)	(-3.005)
No. of children (0-14)	0.005	0.023	-0.009	-0.007	0.028*	-0.031
	(0.289)	(1.324)	(-0.545)	(-0.307)	(1.958)	(-1.622)
No. of female adult	-0.018	-0.035	-0.032	-0.013	-0.005	-0.041
	(-0.568)	(-1.004)	(-1.075)	(-0.320)	(-0.185)	(-1.320)
No. of male adult	-0.009	0.057*	-0.017	0.038	0.071***	0.032
	(-0.281)	(1.819)	(-0.585)	(0.978)	(3.057)	(1.036)
Female headed hhd=1	0.031	0.007	0.058	0.037	-0.082*	-0.002
	(0.416)	(0.119)	(0.943)	(0.378)	(-1.824)	(-0.025)
Age head	0.001	0.001	0.009***	0.004	0.005***	0.006***
	(0.540)	(0.644)	(5.310)	(1.410)	(3.524)	(2.715)
No. year of schooling of head	0.006	-0.000	-0.034***	0.017	0.012	-0.037***
	(0.543)	(-0.023)	(-3.838)	(1.266)	(1.401)	(-3.562)
Member of farm cooperative	0.039	-0.033	-0.198***	-0.081	0.103*	-0.287***
	(0.536)	(-0.500)	(-3.337)	(-0.810)	(1.819)	(-4.734)
Distance to market, min	0.001	0.000	0.000	0.001	0.000	-0.000
	(0.938)	(0.172)	(0.493)	(0.684)	(0.504)	(-0.104)
Distance to main road, min	-0.001*	-0.001	-0.000	0.001	-0.001*	0.000
	(-1.718)	(-0.698)	(-0.142)	(0.611)	(-1.922)	(0.613)
% of high quality soil	0.314***	0.174**		0.307***	0.203***	
	(4.237)	(2.309)		(3.132)	(3.330)	
% of medium quality soil	0.317***	-0.054		0.300**	0.059	
	(3.366)	(-0.537)		(2.413)	(0.820)	
% of wetland	-0.087	0.154		-0.075	0.108	
	(-0.541)	(0.999)		(-0.390)	(0.849)	
% of irrigated land	-0.163	0.064		-0.237	0.063	
	(-0.972)	(0.590)		(-1.162)	(0.582)	
VPU program in village			0.011			-0.038
			(0.199)			(-0.589)
Sale value of hhd assets, in USD1000			-0.828***			-0.326
			(-3.138)			(-1.188)
Sale value of livestock, in USD1000			-0.348***			-0.276***
			(-3.079)			(-2.624)
No. adult children in village			-0.009			-0.051
			(-0.297)			(-1.579)
Hd born in the village=1			-0.077			-0.089
			(-1.204)			(-1.274)
Hd was displaced=1			0.027			0.012
			(0.486)			(0.210)
Listen to the news at least once a week			-0.303***			-0.255***
			(-5.263)			(-4.067)
Head/spouse holds political office			-0.114			-0.259***
			(-1.441)			(-3.503)
Relatives holds political office			-0.115*			-0.243***
			(-1.865)			(-4.157)
Distance to MFI, min			-0.001			0.000
			(-0.962)			(0.477)
Sigma	1.008*	0.993**		1.031*	0.956**	
Rho	0.357	0.243		0.525	0.264**	
Log-Likelihood		-6,302.39			-5,873.30	
chi2		236.729			352.862	
chi2_c		3.260			10.755	
Number of observations		3,119			3,117	

Note: District dummies not reported. t-stats in parenthesis. T-test * significant at 10%; ** at 5%; *** at 1% ***. Standard errors clustered at the village level. Constant included but not reported due to space constraints.

Table 7: Determinants of participation in off-farm activities: multivariate probit estimation

	Nonfarm self-employment	Nonfarm wage labor	Farm wage labor
Female headed household	-0.141*	-0.214***	0.036
	(-1.929)	(-2.722)	(0.485)
Age of household head in years	-0.016*	-0.005	-0.016*
	(-1.799)	(-0.545)	(-1.695)
Age of household head squared	0.000	-0.000	0.000
	(1.021)	(-0.153)	(0.458)
Number of years of schooling of head	0.086***	-0.011	-0.059**
	(3.777)	(-0.445)	(-2.305)
Number of years of schooling of head squared	-0.011***	0.008***	-0.000
	(-3.928)	(2.817)	(-0.129)
Number of children (0-14)	0.024	-0.004	0.089***
	(1.388)	(-0.224)	(4.792)
Number of female adults	-0.010	0.102***	0.280***
	(-0.321)	(2.944)	(7.873)
Number of male adults	0.051	0.265***	0.138***
	(1.548)	(8.332)	(3.646)
Head was born in the village of residence	-0.124*	0.041	0.074
	(-1.749)	(0.549)	(1.041)
Head was displaced	0.107*	-0.032	0.059
	(1.808)	(-0.529)	(0.995)
Log total land owned in hectares	0.097***	-0.039*	-0.209***
	(4.020)	(-1.737)	(-9.289)
Sale value of household assets in USD1000	0.529**	1.169***	-10.199***
	(2.264)	(4.899)	(-7.152)
Sale value of livestock in USD1000	0.003	-0.298***	-0.920***
	(0.030)	(-2.706)	(-5.655)
Remittances and other transfer income in USD1000	-0.075	-0.307**	0.173
	(-0.831)	(-2.450)	(1.363)
Total amount borrowed in USD1000	0.956**	0.257	-1.154**
	(2.437)	(1.036)	(-2.156)
Constrained in the semi-formal credit market	-0.220***	-0.039	0.141**
	(-3.828)	(-0.603)	(2.321)
Time to the nearest market in hours	-0.122**	-0.040	0.074
	(-2.470)	(-0.827)	(1.244)
Time to the nearest main road in hours	-0.034	-0.053	0.052
	(-0.694)	(-1.200)	(0.991)
Constant	-0.066	-1.244***	-0.539*
	(-0.234)	(-4.127)	(-1.806)
Log pseudolikelihood		-4,560.40	
Wald chi2 test		1,921.435***	
Error term correlation between columns 1 and 2, ρ_{21}		-0.103	
Error term correlation between columns 1 and 3, ρ_{31}		-0.203	
Error term correlation between columns 2 and 3, ρ_{32}		-0.295	
Likelihood ratio test of $\rho_{21} = \rho_{31} = \rho_{32} = 0$: chi2(3)		125.534***	
Number of observations		3,235	

Note: District dummies included, but not reported. Robust t-stats adjusted for clustering at the village level in parenthesis: * significant at 10%; ** at 5%; *** at 1% ***.

Appendix Table 1: Descriptive statistics at household level

	Total	Q1	Q2		Q3		Q4	
Household characteristics								
Female headed hhd=1	0.28	0.43	0.28	***	0.23	**	0.19	**
Number of children (0-14)	2.09	1.88	2.01	*	2.11		2.43	***
No. female adults	1.31	1.12	1.25	***	1.32	*	1.53	***
No. male adults	1.10	0.77	1.04	***	1.17	***	1.43	***
Age head	46.32	48.56	46.76	**	45.13	**	46.16	
No. years of schooling head	3.21	2.01	2.61	***	3.45	***	4.64	***
Asset endowments								
Total land owned	0.65	0.24	0.44	***	0.60	***	1.31	***
% of high quality soil	0.36	0.35	0.34		0.37		0.37	
% of medium quality soil	0.15	0.14	0.16		0.15		0.14	
% of wetland	0.07	0.07	0.07		0.08	*	0.08	
% of irrigated land	0.05	0.04	0.04		0.06	**	0.06	
Total borrowed, USD	23	8	11	**	24	***	48	***
Sale value of hhd assets, USD	56	5	15	***	38	***	159	***
Sale value of livestock, USD	163	32	94	***	184	***	363	***
Social capital								
No. of adult children in village	0.36	0.46	0.42		0.34	*	0.27	
Hd born in the village	0.71	0.70	0.70		0.75	**	0.68	***
Hd displaced	0.47	0.47	0.42	**	0.51	***	0.49	
Member of farm cooperative	0.22	0.16	0.21	**	0.27	***	0.26	
Listen to the news at least once a week	0.69	0.39	0.68	***	0.82	***	0.89	***
Head/Spouse holds political office	0.10	0.03	0.08	***	0.12	***	0.19	***
Relative holds political office	0.21	0.16	0.20	**	0.23		0.26	*
Distance to the market, min	371	433	407		343	***	303	*
Distance to the main road, min	276	331	283	*	271		231	*
Input use and agricultural productivity								
Used chemical fertilizer	0.17	0.10	0.13	*	0.20	***	0.24	**
Used manure	0.73	0.66	0.71	**	0.76	**	0.80	*
Used pesticides	0.13	0.08	0.10	*	0.14	**	0.18	*
Used improved seed	0.26	0.17	0.21	**	0.31	***	0.35	*
Used extension advice	0.19	0.14	0.14		0.24	***	0.25	
Male family labor days per ha	136	132	157	*	146		101	***
Female family labor days per ha	326	462	339	***	299		199	***
Used hired labor	0.43	0.22	0.31	***	0.48	***	0.74	***
Hired labor days per ha	146	150	124		122		154	*
Total labor days per ha	488	656	537		465		418	
Yield per ha in USD	444	474	417	**	443		439	
Total Observations	3600	823	824		823		824	

Source: Own computation from WB survey 2011.

Note: The wealth quartiles are calculated using a principal component analysis based on housing conditions, assets, livestock and land ownership. T-test is performed using the immediate lower quartile as a reference: * significant at 10%; ** significant at 5%; *** significant at 1%

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