Direct Elicitation of Credit Constraints: Conceptual and Practical Issues with an Application to Peruvian Agriculture

STEPHEN R. BOUCHER
University of California, Davis, and Giannini Foundation of Agricultural Economics

CATHERINE GUIRKINGER
University of Namur, Belgium, and Centre of Research in the Economics of Development (CRED)

CAROLINA TRIVELLI
Instituto de Estudios Peruanos, Lima

I. Introduction

How important are credit constraints in the process of economic development? Economic theory suggests that credit constraints may have significant negative impacts on income and welfare, especially for poor households. Ex ante credit constraints prevent individuals from undertaking desired activities and from realizing profit-maximizing investment levels in the activities they do engage in. Thus entrepreneurially talented but poor individuals are prevented from starting businesses while liquidity-strapped farmers are unable to purchase a critical pesticide to fend off a pest infestation. By preventing gains from trade, ex ante credit constraints result in income-enhancing opportunities being left on the table. Ex post credit constraints prevent individuals from borrowing after investment decisions have been made and production outcomes realized. As demonstrated by Eswaran and Kotwal (1989, 1990) ex post credit constraints both directly reduce welfare by preventing individuals from borrowing to smooth consumption when income flows are risky and indirectly reduce income and welfare by making risk-averse individuals less likely to enter high-return but risky activities in the first place. Taken together, ex ante and ex post credit constraints may have strong implications for the likelihood that

households fall into or climb out of poverty traps (Zimmerman and Carter 2003; Carter and Barrett 2006), as well as for the level and distribution of income in the overall economy (Banerjee and Newman 1993; Aghion and Bolton 1997).

Considering the potentially far-reaching consequences of credit constraints suggested by theory, empirical evidence that effectively identifies the causal impacts of the multiple potential forms of credit constraints is relatively scarce. The lagged response of the empirical literature can be attributed, in part, to the challenge of econometrically identifying the impact of credit constraints. Ideally (at least from an economist's point of view) the economist would analyze a situation in which individuals, households, or firms are randomly, or exogenously, assigned to be either credit constrained or unconstrained. Differences in outcomes, such as the probability of starting a business, the level of investment and profit, or the smoothness of consumption, could then be clearly attributed to the credit constraint.

Recently, several researchers have proceeded along this line of randomization. Banerjee and Duflo (2004) use an exogenous change in credit policy in India that increased the supply of credit to medium-sized firms to achieve identification. Karlan and Zinman (2009) take a more direct approach. They worked with a consumer lender in South Africa to run an experiment whereby a randomly selected group of loan applicants who would normally be rejected were instead offered loans. A third example of this randomization approach comes from research underway by de Mel, McKenzie, and Woodruff (2008) in Sri Lanka, in which the authors randomly select a group of microentrepreneurs to receive a gift of capital, either in the form of machinery or cash. Again, a comparison of profit and investment across the lucky recipients versus the unlucky nonrecipients can identify the impact of credit constraints.

While policy and field experiments provide a clean way of gauging the impacts of credit constraints, their use is still relatively limited. Relevant policy experiments are extremely rare, and field experiments, while having great promise, are fraught with their own challenges of design, implementation, financing, and generalizability.

Beginning with papers by Feder et al. (1990) and Jappelli (1990), several authors have followed an alternative approach that relies on more conventional survey-based research, albeit with a methodological twist. This "twist" consists of adding a set of questions that directly elicits the household's or firm's status as either credit constrained or unconstrained. With the observed separation of the sample into those that are constrained versus unconstrained, the researcher can directly evaluate the impacts of credit constraints on the efficiency of resource allocation. Examples of this approach, which we call the direct elic-

itation methodology (DEM), include Carter and Olinto (2003), who examine the impact of credit constraints on investment levels in Paraguay; Petrick (2004), who evaluates the impact of credit constraints on farm output in Poland; and Foltz (2004), who evaluates the impact of credit constraints on farm profit in Tunisia.

Given the centrality of financial markets to the process of development, the strengthening of empirical methodologies for identifying credit constraints warrants a high priority among research objectives. By describing, evaluating, and suggesting extensions to the DEM, this article represents a step in this direction. Our objectives are fivefold. First, we provide a general discussion of the concept of credit rationing. This discussion is important because differences in empirical strategies for measuring credit constraints as well as evaluation of the impact of constraints can originate in definitional differences. To facilitate this discussion, we develop a simple model to demonstrate that asymmetric information can give rise to three different "mechanisms" of nonprice rationing—quantity, transaction costs, and risk. Second, we provide a detailed description of the DEM and discuss four important issues and challenges faced by the researcher in its implementation. As we will make clear, identifying the constraint status of individuals who do not participate in the credit market is particularly challenging, requiring a series of counterfactual questions. Our third objective is to provide evidence, using a data set from rural Peru, that the DEM captures the underlying motivations for nonparticipation. Fourth, we use the same data to demonstrate the importance of accounting for all three forms of nonprice rationing by estimating the impacts of credit constraints on farm productivity under two alternative definitions: a "restrictive" definition, in which only quantity-rationed households are considered constrained, and a "comprehensive" definition, which also includes transaction-cost and risk-rationed households as constrained. Finally, we conclude by offering suggestions for improving methodologies for identifying credit constraints.

II. Nonprice Rationing: A Conceptual Framework

In this section we develop a simple model of a credit market and activity choice.[1] Our goal is to introduce the three different types of nonprice rationing—quantity, transaction costs, and risk. All three forms of nonprice rationing arise because of information and enforcement problems associated with loan contracts, and they prevent households from realizing profitable

[1] For a recent review of the theoretical literature on quantity rationing, see Udry and Conning (2005).

projects. Thus, households facing any of these three forms of nonprice rationing are effectively constrained in the credit market. While quantity-rationed households are denied access to loans, risk- and transaction-cost-rationed households instead voluntarily withdraw from the credit market because of the nonprice terms of available contracts. It is particularly important to account for credit constraints deriving from these latter two forms of nonprice rationing because the types of policies that can alleviate them may be quite different from those designed to alleviate quantity rationing.

A farmer owns T acres of land and produces with a Leontief-style technology requiring a fixed investment per acre, which, for simplicity, we assume is \$1. The farmer has no liquidity and thus requires a loan to finance production. The value of the farmer's nonliquid assets, including land and machinery, is A. There are two possible states of nature—success and failure—that occur with probabilities p and $1 - p$, respectively. Revenue per unit land under success is Y; under failure, it is zero. The farmer's reservation activity is to rent out the land and earn w per unit land. Risk-neutral lenders operate in a perfectly competitive market and have an opportunity cost of capital equal to $1 + r$. Assume that $pY > 1 + r + w$, so that, evaluated at the lender's opportunity cost of capital, production is more profitable than renting out the land.

A. Symmetric Information and the First-Best

We begin by assuming that lenders can costlessly observe all relevant borrower characteristics and actions; that is, they do not confront adverse selection or moral hazard. A credit contract then specifies the borrower's repayment obligation under each state of nature. Letting i denote the interest rate and k denote the collateral requirement per unit land, the borrower repays $T(1 + i)$ under success and Tk under failure. The borrower's consumption in state j, C_j, is thus

$$C_j = \begin{cases} A + T[Y - (1 + i)] & \text{if } j = \text{success,} \\ A - Tk & \text{if } j = \text{failure.} \end{cases} \tag{1}$$

The lender's return per hectare, R_j, is

$$R_j = \begin{cases} i - r & \text{if } j = \text{success,} \\ k - (1 + r) & \text{if } j = \text{failure.} \end{cases} \tag{2}$$

The optimal contract solves the following program:

$$\max_{i,k} EU(C_j),$$

subject to :

$$1 + i \quad \geq \quad \frac{1 + r}{p} - \frac{1 - p}{p}k, \tag{3}$$

$$kT \leq A. \tag{4}$$

Equation (3) is the lender's participation constraint, and it ensures that the lender earns a nonnegative return. Equation (4) is the limited liability constraint; it acknowledges that, at most, the borrower can post collateral worth A. Using equation (1) in the above program, it is easy to show that, under the optimal contract, the borrower would earn the entire surplus (constraint [3] binds) and fully smooth consumption across states of nature. This simple model highlights the dual functions of the credit market as provider of both liquidity and, potentially, insurance. In the absence of information problems, lenders would be indifferent between contracts that trade lower collateral for higher interest rate at the rate of $(1 - p)/p$. Efficient risk sharing would be achieved with the borrower paying a relatively high interest rate while fully insuring his consumption against production risk. Thus, even in the absence of a well-functioning insurance market, all socially desirable investments would be made if credit markets were perfect. We denote the farmer's credit demand in this first-best world as his *notional demand*.

B. Asymmetric Information and Nonprice Rationing

As is well established in the theoretical literature, the presence of asymmetric information between borrowers and lenders results in problems of adverse selection and moral hazard, which may significantly alter the performance of credit markets relative to the first-best world. A common response of lenders to these information problems is to require collateral. By providing incentives for borrowers to take actions that reduce the probability of failure, collateral addresses moral hazard (Hoff and Stiglitz 1990). Collateral may also serve as a mechanism for sorting borrowers of unobserved types (e.g., project riskiness), and it thereby also addresses adverse selection (Bester 1987). We acknowledge the presence of asymmetric information in our model by assuming that lenders require that borrowers post a minimum of $\underline{k}$ units of collateral per unit land

financed.[2] In addition, we assume that posting any amount of collateral implies a fixed cost, F, to the borrower.[3] In terms of our optimization program, we add an additional constraint: $k \geq \underline{k}$.[4] While the lender is still willing to trade interest rate reductions for collateral increases at a rate of $(1 - p)/p$, he is only willing to do so over a restricted range of contracts with sufficiently high collateral. This restriction of the feasible contract set gives rise to the first form of nonprice rationing, namely, *quantity rationing*. Farmers who cannot post the minimum required collateral ($A < T\underline{k}$) are involuntarily excluded from the credit market. Quantity rationing occurs when a farmer has a profitable project, and thus positive notional demand for credit, but faces zero supply.

As pointed out by several studies (Jappelli 1990; Mushinski 1999; Boucher et al. 2008), even though an agent both has positive notional demand and faces a positive supply, he may not have positive *effective demand*, defined as the demand for contracts available in the "actually existing" or asymmetric information world. There are two reasons that an agent who could obtain a loan to invest in a profitable activity would choose not to borrow. First, transaction costs reduce the expected income associated with a credit contract by F. As a result, a contract yields greater expected income than the reservation activity if $pY > 1 + r + w + (F/T)$. A farmer who has positive notional demand but zero effective demand because of the size of transaction costs is called *transaction-cost rationed*.

Second, the collateral requirement forces the borrower to bear a minimum amount of risk and thus may drive the borrower's expected utility below his reservation utility, even though taking the credit contract would raise expected consumption. In this case the borrower is *risk rationed*—he has access to an expected income-enhancing contract but chooses to withdraw from the credit market to instead undertake the lower return but certain reservation activity.

To summarize, asymmetric information can give rise to three types of non-price rationing. The first, quantity rationing, has been emphasized in both the theoretical and empirical literature. Quantity rationing is a supply-side constraint and occurs when a borrower's effective demand exceeds supply. It reflects the reduction in the lender's willingness to offer contracts resulting

---

[2] While a complete model would endogenize k, that is beyond the scope of this article. Instead, we simply assume $\underline{k}$ exists and is the same for all borrowers. See Boucher, Carter, and Guirkinger (2008) for an example of a model that endogenizes the collateral requirement in a model of moral hazard.

[3] Posting collateral typically requires verification of property deeds, verification that the property is not mortgaged to another party, and the actual registration of the mortgage itself. Each of these transactions implies a trip to the property registry and a fee.

[4] This constraint is essentially an incentive compatibility constraint in a model of moral hazard.

from the presence of asymmetric information. In contrast, both transaction cost and risk rationing reflect the reduction in credit demand that may result from asymmetric information. Any evaluation of the performance of credit markets should incorporate these three nonprice rationing mechanisms, as each implies that profitable investments are forgone. Similarly, efforts aimed at overcoming credit constraints must identify the relative importance of each of these mechanisms, as they require a different set of policies. The first step in that direction is to identify which households are credit constrained and by which mechanism.

III. Eliciting Credit Constraints: A Practical Approach

In this section, we outline a strategy to directly elicit credit constraints. We first define unconstrained and constrained households based on the relationships among household-specific supply, notional demand, and effective demand. We then examine how these definitions can be operationalized in household surveys. Finally, we discuss four central issues that arise in the direct elicitation approach. Much of this discussion is based on lessons learned from our accumulated efforts to elicit credit constraints in household surveys in Guatemala (Barham, Boucher, and Carter 1996), Honduras and Nicaragua (Boucher, Barham, and Carter 2005), and Peru (Guirkinger and Trivelli 2006; Guirkinger and Boucher 2008).

A. Defining Constraint Categories

Let D_i^E and D_i^N denote, respectively, the effective and notional demands for credit of household i. Similarly, let S_i denote the credit limit, or the maximum amount of credit a lender is willing to supply to the same household. The conceptual discussion from Section II implies that a household (or individual or firm) will fall into one of three mutually exclusive categories: unconstrained, supply-side constrained, and demand-side constrained. We describe each in turn.

Unconstrained, or price-rationed, households are unaffected by asymmetric information in credit markets. The following relationship holds for unconstrained households:

$$D_i^E = D_i^N \leq S_i. \tag{5}$$

While asymmetric information may imply that lenders impose a credit limit, this limit is not binding for unconstrained households. Depending on their endowments and opportunities, unconstrained households may be either borrowers ($D_i^E > 0$) or nonborrowers ($D_i^E = 0$).

Supply-side-constrained, or quantity-rationed, households face a binding credit limit and are characterized by the following relationship:

$$S_i < D_i^E \leq D_i^N. \tag{6}$$

Note that while asymmetric information may reduce these households' effective demand relative to their notional demand, the limiting constraint comes from the supply side. As such, we expect these households to demonstrate excess demand. We take up the question of how to detect this excess demand in practice in the next section.

Finally, *demand-side-constrained* households do not face a binding credit limit and thus do not express excess demand. They are described by the following two relationships:

$$D_i^E < D_i^N, \tag{7}$$

$$D_i^E \leq S_i, \tag{8}$$

The first inequality implies a wedge between notional and effective demand due either to the risk-sharing rules of the best contract available or the transaction costs associated with loan application. The second inequality implies that the limiting constraint comes from the demand side.

B. Operationalizing Constraint Categories

The classification of a household's constraint status typically draws on two modules within the credit section of a household survey. Figures 1 and 2 provide examples of these two modules. Figure 1 depicts the first half of the "loan characteristics module" from the survey of farm households in Peru that will serve as the basis for the empirical analyses of Sections IV and V. This module collects information to characterize loan contracts and is administered to households that borrowed during the recall period. Figure 2 consists of two portions. The upper portion (above the dotted line) depicts a "credit market perceptions module" used to describe experiences in, and perceptions of, the credit market for households that did not borrow during the recall period. The bottom portion of figure 2 does not appear in the survey but instead shows how nonborrowers' responses lead to the classification of their constraint status and rationing mechanism.

1. Identifying Supply-Side-Constrained Households

We now turn to operationalizing the classification scheme described above. We begin with supply-side-constrained households. Equation (6) will hold if a household received less than its desired amount of credit given the terms of contracts available in the market. In identifying supply-side-constrained

Figure 1. Sample loan characteristic module (first 21 questions)

list of loans	2. Name of the lender	3. Type of lender	4. Which household member received the loan?	5. What was the loan used for?	6. For what crop did you request the loan?	7. How was the loan disbursed? 1.Only in cash >> 11 2.Only in kind >> 8 3.Both in cash and kind>>8	8. What was the value of inputs you received?		9. If you would have bought these inputs in cash, would you have paid : 1.More >> 10 2.Less >> 10 3.The same >> 11	10. What would be the % difference if you would have bought them in cash?	11. Would you have wanted a larger loan at the same interest rate? 1.yes >> 12 2.no>>14	12. How much more would you have wanted?		13. Why did you not receive what you wanted? See below
		See below	Individual code	See below			Amount	Mn. 1.S/. 2.$		Mn. 1.S/. 2.$		Amount	Mn. 1.S/. 2.$	
01														
02														

Codes

Question 3

Formal
1.Commercial bank
2.Rural bank
3.Municipal bank

Semi-Formal
5.Government program
6.Cooperative
7.Producer association
8.NGO

Informal
9.Input supplier
10.Rice mill
11.Textile company
12. Grain trader
13. Grocery store
14. Relative, friend
16.Other___

Question 5
5. Start a new business>> 7
6. Spending related to the business>> 7
7. To buy material for the business>> 7
8.Education>> 7
9.Consumption>> 7
10.House improvement>> 7
11.Buy or build a house>> 7
12.Other___ >> 7

(Column 7 codes)
1.To buy inputs >> 6
2. To install perennial crops>>
6 To buy agricultural material. >> 7
3. To buy agricultural material. >> 7
4. Other agricultural investment ___ >> 7

Question 13
1. Lack of collateral
2. Project not profitable enough
3. Lending policy of the institution
4.other___

listo f loans	14. Do you have to pay interest on this loan? 1.Yes>>15 2.No>>16	15. What is the interest rate?			16. When did you receive this loan?		17. How often do you pay installments?	18. How much do you pay in each installment?		19. How many installments will you pay in total?	20. In total, how much will you pay to cancel this loan?		21. When will you finish paying?	
		rate	time period		month	year		Amo unt	Mn. 1.S/. 2.$		Amount	Mn. 1.S/. 2.$	Month	Year
		(%)	1.daily 2.weekly 3.monthl y	4.Annually 5.Other___	(1-12)		1.daily 2.weekly 3.monthly 4.annually 5. once at the end>>20 6. it is not fixed>>20						1-12	
01														
02														

1. *[Instructions: Do not read this question out loud.]* According to the Loan Characteristics Table, did this household receive any loan from a commercial bank in the past 12 months?

Yes → *Skip to the next section*   No → *Continue with question 2*
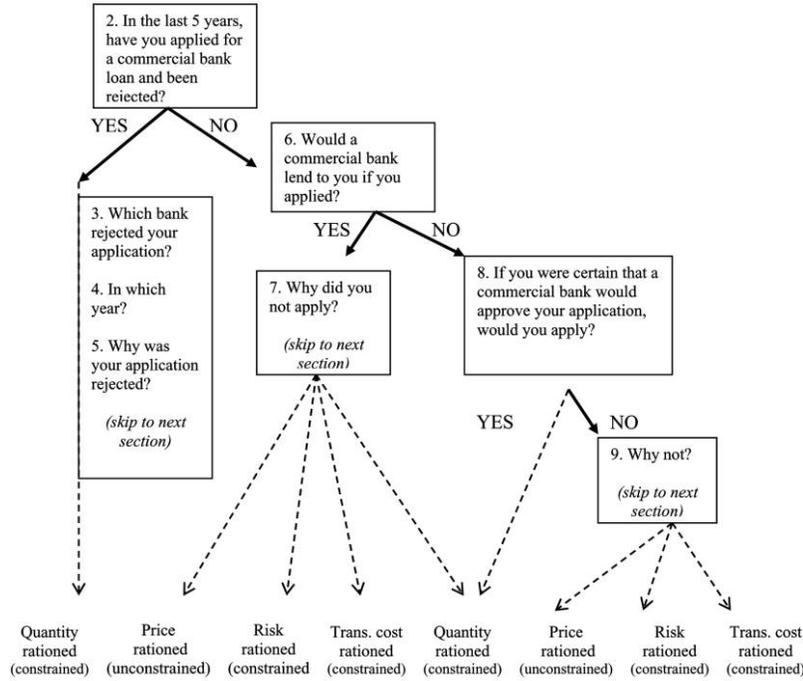
Figure 2. Sample nonborrower perceptions module

households from survey data, it is useful to distinguish three separate groups. The first group consists of unsatisfied borrowers. These individuals received a loan, but the loan amount was less than their effective demand. To identify this group, we use the response to question 11 in figure 1, "Would you have wanted a larger loan at the same interest rate?" There are two details to note in the formulation of this question. First, the borrower is asked to compare the amount she received to the amount that she wanted. While it might seem more intuitive to compare the amount received with the amount applied for, this would be problematic inasmuch as the borrower may know the lender's supply rule and thus have only applied for the amount she qualified for. Second, the question emphasizes that the desired amount is conditional upon the interest rate. In practice, when asked without conditioning on the interest rate, respondents often interpreted the question as asking for their total working capital needs under an interest-free loan.[5]

---

[5] Although not essential for our present purpose of discrete categorization of constraint status,

The second group is rejected applicants, who have positive effective demand but a zero credit limit. As this group did not borrow, they are identified using the credit market perceptions module. In figure 2, this group responds "yes" to question 2, which asks if they have applied and were rejected. A specific issue is the time frame specified in this question. If a household's credit limit were time invariant, then the appropriate question would be whether or not the household has ever been rejected. If, as is more likely, the credit limit changes over time, then a shorter recall period is preferable. Questions 3, 4, and 5 are not necessary for the constraint classification; however, they provide quantitative information on loan demand as well as qualitative information on perceived reasons for loan rejection.

The final supply-side-constrained group is "certainly rejected" nonapplicants, who had positive effective demand but did not apply for a loan because—based on past experience or their perceptions of lenders' supply rules—they were certain their loan application would be rejected. As these are nonborrowers, we again use the perceptions module to classify their constraint status. Given that they did not apply for a loan, they are filtered to question 6, which asks if they believe the lender would offer a loan if they applied. If "yes," then we know that the household is not supply-side constrained. If "no," the enumerator continues with question 8: "If you were certain that a lender would approve your application, would you apply?" If "yes," then the household is classified as constrained.[6]

2. Identifying Demand-Side-Constrained Households

As in the case of supply-side constraints, demand-side-constrained households can be either borrowers or nonborrowers. In both cases these households' effective demand is reduced by transaction costs or risk. Our discussion here will focus on how to identify demand-side-constrained nonborrowers.[7]

Begin at question 6 in figure 2, which asks, "Would a bank lend to you

---

question 11 is followed by a question that asks the desired loan size. This identifies a point on the borrower's demand curve and is thus useful to analyze continuous loan demand and estimate the shadow value of liquidity.

[6] One specific issue to be aware of is the wording of question 8. Notice that we do not ask "Would you accept a loan if you were offered one?" The reason is that the word "offered" may imply that the respondent need not incur the costs of application.

[7] Ignoring demand-side-constrained borrowers is likely to have little impact on the evaluation of the performance of credit markets for two reasons. First, since transaction costs typically have an important fixed component, they should have relatively little impact on effective demand for those who borrow. Second, the scope for borrowers to reduce risk by taking smaller loans is limited because collateral assets are typically lumpy and cannot be marginally adjusted and many agricultural lenders offer boilerplate loan contracts in which loan size is a fixed multiple of area cultivated.

TABLE 1
COMMON REASONS GIVEN FOR LACK OF EFFECTIVE DEMAND

Why did (would) you not apply for a formal loan?
Unconstrained (price rationed):
A. I do not need a loan.
B. The interest rate is too high.
C. Farming does not give me enough to repay a debt.
D. I prefer working with my own liquidity.
Constrained (risk rationed):
E. I don't want to put my land at risk.
F. I do not want to be worried; I am afraid.
G. Formal lenders are too strict; they are not as flexible as informal ones.
H. Formal lenders do not offer refinancing.
Constrained (transaction-cost rationed):
I. The branch is too far away.
J. There is too much paperwork; the costs associated with loan application are too high.

if you applied?" Demand-side-constrained nonborrowers are found among both those with and without perceived access. Households that answer "yes" to question 6 and thus believe they have credit access are then asked why they did not apply (question 7). Their response to this question, as discussed below, allows their classification as unconstrained or constrained and, if constrained, as transaction-cost rationed or risk rationed. Households that answer "no" to question 6 and thus believe they have no credit access are then asked in question 8 whether they would want a loan if they were certain the lender would approve their application. As discussed above, those who say "yes" are the certainly rejected nonapplicants and are classified as supply-side rationed. Those who say "no" are then asked "why not" in question 9 and classified as unconstrained or constrained and, if constrained, as transaction-cost rationed or risk rationed.

As should be clear by now, one of the main objectives of this method is to gather additional information on the credit market perceptions of nonborrowers. In particular, determining constraint status requires learning why some households choose not to borrow even though they believe they qualify for a loan. In figure 2, questions 7 and 9 elicit this information. Table 1 provides typical responses to these questions and the subsequent classification of households. Recall that unconstrained nonborrowers have zero notional demand and no profitable projects that require outside financing. This group can be highly diverse, including households with large endowments of productive assets and liquidity as well as endowment-poor households with limited investment opportunities. Response C, "Farming does not give enough to repay a debt," is a common response from this latter type of unconstrained household. Other frequent responses suggesting that the household is unconstrained include "The interest rate is too high" and "I don't need a loan." Some responses do not lend

themselves to an unambiguous classification. For example, the response D, "I prefer working with my own liquidity," could be consistent with both price rationing and risk rationing.[8] For these responses, we suggest following a conservative approach and classifying the household as unconstrained.

A demand-side-constrained household, in contrast, has a profitable investment beyond its own liquidity that it forgoes due to risk or transaction costs. Rows E–H of table 1 provide examples of responses associated with risk rationing. Of these, the most common response in each of the surveys we conducted was "I don't want to risk my land."[9] Rows I and J are common responses indicating that the household was discouraged from borrowing by transaction costs. It is important to note that we interpret responses E–J as indicating that households have a profitable use for credit (i.e., have positive notional demand) and have considered taking a loan but have decided not to because of risk or transaction costs.

C. Issues and Challenges in Classification via Direct Elicitation

Several important issues and challenges arise when using the DEM. We discuss what we consider to be the four most important. The first two involve choices about how to define units of analysis when designing the questionnaire. The second two are related to the DEM's partial reliance on hypothetical and counterfactual questions—as opposed to observed actions—to identify the constraint status of respondents who do not participate in the credit market.

1. Issue 1: Definition of Loan Sectors

The first issue to consider in designing the perception module is how the lender is defined to the respondent. In practice, rural credit markets are composed of heterogeneous lenders, including commercial banks, state banks, nongovernmental organizations (NGOs), and a wide range of informal lenders. Both the access rules and contract terms facing a given household may vary widely across these lenders. As a result, a household may be unconstrained with respect to one type of lender but constrained with respect to other lenders that offer more favorable contracts, for example, with longer maturity or lower cost. In this case, the constraint would be binding and adversely affect the

---

[8] This response could be given by high-liquidity households that are unconstrained, as well as by households with investment opportunities requiring funds beyond their own liquidity but that chose not to borrow because of risk.

[9] The surveys we have conducted were carried out in regions where banks exist and tend to require titled property as collateral. In areas where banks do not operate or where land cannot be used as collateral, risk rationing can still occur but is likely to manifest itself via different responses. For example, risk rationing may be quite common in villages dominated by a stereotypical moneylender who requires the borrower to put up his reputation or "knee-caps" as collateral.

household's resource allocation. Given this concern, lenders should be grouped into distinct sectors, or segments, of the credit market, and the language of the qualitative questions in the perceptions module should be cast with respect to these sectors.

Another reason to define distinct loan sectors is to test sector-specific hypotheses. For example, we might be interested in evaluating a policy that affects a certain type of institution. Mushinski (1999) uses the direct elicitation approach to evaluate the impact of market-oriented reforms implemented by credit unions in Guatemala on the prevalence of nonprice rationing in the credit unions. We also might be interested in testing the existence of a preference hierarchy across loan sectors. Until recently, most theoretical and empirical models assumed that the formal loan sector is strictly preferred by all borrowers (Bell, Srinivasan, and Udry 1997). Several authors have challenged this assumption, arguing that informal contracts may be preferred because of lower cost (Chung 1995; Kochar 1997) or lower risk (Boucher and Guirkinger 2007). Appropriately defining sectors allows testing of these hypotheses.

2. Issue 2: Household versus Individual Constraints

The second definitional issue is whether the credit constraint classification should be defined at the household or individual level. Until now, we have couched the discussion at the household level. This approach is appropriate if we believe household resource allocation is consistent with a "unitary" household model in which endowments and income are pooled among household members. The qualitative questions of the perceptions module would then be addressed to the household head, who would respond for the overall household. We assume that the head can, given the endowments and opportunities available to the household, assess the effective and notional demand of—as well as the supply available to—the entire household.

If, in contrast, resources are not pooled within the household or information is not shared, then individual characteristics—including whether or not individuals are credit constrained—may have an impact on the household's resource allocation. In this case, each individual's constraint status needs to be elicited, and thus the perception module is applied to each adult in the household. This individual approach, while costly, is useful for testing hypotheses related to gender bias in credit access and intrahousehold resource allocation processes. It has been used by Diagne, Zeller, and Sharma (2001) in an exploration of credit markets in Malawi and by Fletschner (2008) in Paraguay.

3. Issue 3: Use of Respondents' Perceptions of Lender Supply Rules

In order to classify nonborrowers as constrained or unconstrained, the perceptions module relies on several hypothetical questions. Identification of supply-side constraints hinges on question 6, which asks nonapplicants if they believe a bank would lend to them if they were to apply. There are two potential concerns associated with the use of this question. First, the respondent may not understand the question. Until this point in the survey, the respondent has been bombarded with "factual" recall questions, such as the reconstruction of farm revenues and costs. Question 6 requires the respondent to change gears and think about the outcome of a loan application that was not made. Clearly communicating this type of question is a nontrivial task. Beyond a clear phrasing of the question itself, effective use of this type of hypothetical question requires careful selection and training of enumerators, who may need to step outside of the literal question in order to convey the idea.

The second issue is that identification of a binding supply constraint relies on the respondent's perception of the lender's willingness to offer them a loan. This perception may be incorrect. For our objective of gauging the impacts of credit constraints on resource allocation, however, a respondent's misperception of a lender's true supply rule is not problematic. Consider two individuals with positive effective demand who are identical except in their perceptions of the lender's supply rule. The first correctly believes he faces positive supply and thus ends up taking a loan and carrying out the investment project. The second incorrectly believes he faces zero supply. As a result, he does not apply and forgoes the project. These two households would be classified as credit unconstrained and constrained, respectively. The difference in their resource allocations is determined by the difference in their perceived supply rule, which is captured by the DEM, rather than the "true" supply rule. The misperception thus does not cause a classification error. Next consider a nonapplicant who incorrectly believes that a lender would offer him a loan. Again, this misperception does not result in a misclassification. Since he believes he could get a loan but did not apply, the lender's "true" supply rule does not constrain the respondent. Instead, he is either unconstrained or demand-side constrained, as indicated by his response to question 7 in figure 2.[10]

---

[10] While misperceptions of lenders' supply rules do not imply errors in the DEM's classification scheme, gauging the accuracy of nonborrowers' perceptions is relevant for policy. If households refrain from borrowing because they systematically underestimate lenders' willingness to lend or overestimate the interest rate, risk, or transaction cost of contracts that are available to them, then policies that increase the flow of information to rural households would be more appropriate than policies that seek to change the contract terms themselves.

4. Issue 4: Identifying Notional Demand of Nonborrowers via Subjective Questions
Use of the DEM requires that it accurately capture the rationing mechanism of respondents. Identifying the rationing mechanism of loan applicants is straightforward; the joint outcome of the respondent's action (loan application) and the lender's action (approval or rejection) allows the researcher to sort applicants into those who are price rationed versus those who are quantity rationed. Nonapplicants pose a greater challenge because the fact that they did not apply for a loan does not imply zero notional demand. The DEM proposes identifying notional demand for these respondents by understanding the underlying reasons for their lack of effective demand, that is, why these respondents did not, or would not, apply for a loan. This is accomplished via questions 7 and 9 in figure 2.

The question, and perhaps the central concern of the DEM, is how certain we are that the answers respondents give to these two questions capture their true motivation for not applying. Consider a farmer who says that he did not apply for fear of losing his land. Can we be certain that this individual is risk rationed? Or might this response instead reflect low-quality land and a lack of productive opportunities? If so, then the respondent should be classified as price rationed (unconstrained). Ideally, we would observe whether or not this respondent applies for a loan in a counterfactual world in which loans carried less contractual risk. Ultimately, use of the DEM requires a sufficient degree of certainty that the line of direct questions in the survey accurately captures the true motivations for nonapplication. Given the centrality of this issue, in the next section we provide evidence on the ability of the DEM to effectively distinguish between demand-side-constrained versus unconstrained nonborrowers.

IV. How Reliable Is the DEM? Evidence from Peru
In this section, we address the final, and most important, issue raised in the previous section. We do so by using survey data from Peru to provide evidence on the degree to which the DEM effectively distinguishes between constrained versus unconstrained nonborrowers. We use these same data in the next section to demonstrate the importance of including both supply- and demand-side constraints when evaluating the performance of a credit market.

A. Data Description and the Frequency of Credit Rationing
The data come from a panel survey of farm households in the department of Piura, on Peru's north coast. In 1997, a random sample of 547 farm households was drawn from the comprehensive lists of farmers maintained by the irrigation

TABLE 2
DESCRIPTIVE STATISTICS OF SAMPLE HOUSEHOLDS

	1997	2003
% with:		
Less than 1 hectare	3.8	4.3
Between 1 and 5 hectares	74.3	77.0
Between 5 and 10 hectares	13.3	11.7
More than 10 hectares	8.6	7.0
Median farm size	3.0	3.0
% that own tractor	.9	1.6
% with registered land title	49.4	70.0
% living in peasant community	43.1	43.1
Mean age of head of household	52.0	56.4
Mean schooling of head of household (years)	4.5	4.8

TABLE 3
FREQUENCIES OF RATIONING MECHANISMS

Rationing Mechanism	1997	2003
Unconstrained:		
Price-rationed borrower	28.2	27.8
Price-rationed nonborrower	16.5	28.7
Constrained:		
Quantity rationed	36.6	10.4
Risk rationed	8.6	22.4
Transaction-cost rationed	10.2	10.8

commissions. In 2003, we found and resurveyed 499 of the original households, of which 442 were still farming.

The sample is representative of the irrigated, commercial agriculture of Piura's coast. The descriptive statistics in table 2 provide an overview of these households. The median farm size in the sample is 3 hectares, with over 90% of households farming less than 10 irrigated hectares. This predominance of small farms is a legacy of Peru's agrarian reform of the 1960s and 1970s. Property rights reform was a pillar of the economic liberalization program of the 1990s. In Piura, this is reflected in the increase from 49% to 70% of sample households with a registered property title over the study period.

The survey was designed to measure the incidence and impact of credit constraints in the formal credit sector, which, in Piura, consists of commercial banks, municipal banks (*cajas municipales*), and rural banks (*cajas rurales*). A nonborrower perceptions module similar to the one in figure 2 was repeated for each type of institution to which the household did not apply for a loan. A loan characteristics module captured details of all loans taken from both formal and informal sources. Based on the method described in Section III, we used these two modules to identify each household's rationing mechanism.

Table 3 shows the frequency of each type of rationing mechanism among sample households. Using the comprehensive definition of credit constraint,

which includes quantity, risk, and transaction-cost rationing, the fraction of households that are constrained in the formal credit sector fell from 57% in 1997 to 44% in 2003. Risk- and transaction-cost-rationed households account for a significant fraction of the sample. If we instead use the restrictive definition and only include quantity-rationed households as constrained, these numbers would fall to 37% and 10%. The table also shows that (under the comprehensive definition) credit constraints become less prevalent over time. The reduction in credit constraints is driven primarily by a decrease in quantity rationing. This is consistent with a relaxation of supply-side constraints due to the advances of the land titling program in the period between surveys. The reduction in quantity rationing is partially offset, however, by an increase in risk rationing.

B. Evidence on the Reliability of the DEM

Use of the DEM requires that the subjective questions at the heart of the approach accurately distinguish between those nonapplicants who are constrained versus unconstrained. In this subsection, we use the Peru data to provide initial evidence on the accuracy of the DEM's classification of non-borrowers. Our strategy is to examine correlations between observed rationing categories and various factors that are likely to affect credit supply, the size of transaction costs, and the risk preferences of and background risk faced by sample households. We expect, for example, that risk rationing should be more likely among households that are more risk averse. We begin by comparing means of these factors across rationing categories. To control for likely correlations across these factors, we then estimate a multinomial logit regression of households' observed rationing mechanism against various explanatory variables underlying credit supply and demand, including our proxies for background risk, risk preferences, and transaction costs. As several of the variables we use were only collected in the 2003 survey, the analysis in the remainder of this section is restricted to the 2003 cross section.

Table 4 compares the means of the six correlates across rationing categories.

TABLE 4
COMPARISON OF MEANS OF KEY CORRELATES ACROSS RATIONING MECHANISMS

| | Unconstrained | | | Constrained | |
Variable	Borrowers	Nonborrowers	Quantity Rationed	Risk Rationed	Transaction-Cost Rationed
Title	.785	.611	.508	.736	.449
Distance	17.8	26.4	31.3	30.7	30.9
Informed	.913	.818	.754	.822	.830
CV	.552	.555	.562	.569	.542
RA	.013	.013	.016	.015	.013
Maxinformal	1.07	.54	0.452	.578	.825

The variable Title is the fraction of the household's farm area with a registered property title and is included as a control for credit supply. Titled land is the most common form of collateral used by formal lenders in Piura. In addition, even when a formal mortgage is not established, lenders frequently require the borrower to hand over their title until the loan is repaid in order to prevent borrowers from simultaneously taking loans from other lenders.

The next two variables are proxies for the transaction costs associated with loan application. The variable Distance gives the travel time in public transportation to the nearest formal lender. The variable Informed takes value one if the respondent correctly identified the economics minister and serves as a proxy for the household's knowledge of formal institutions. As the loan application process may require the applicant to interact with formal institutions such as notaries and the property registry, this variable is likely to be negatively correlated with transaction costs.

The final three variables are proxies for environmental risk, risk preferences, and risk-bearing capacity. The variable CV is the coefficient of variation of yields between 1996 and 2006 in the district of the household's farm.[11] Other things equal, we expect the probability of risk rationing to be increasing in the production risk associated with the household's farm location. Holding constant the risk environment, we also expect risk rationing to be more likely for more risk-averse individuals. The variable RA is an individual-specific measure of risk aversion computed using a set of questions included in the 2003 survey.[12] Finally, the variable Maxinformal is the maximum amount of money the household said it could receive from family and friends in case of an emergency. This variable is included as a proxy for the strength of informal insurance networks and is expected to be negatively related to the probability of risk rationing.

A comparison of variable means suggests that the classification delivered by the DEM is roughly consistent with expectations. Compared to unconstrained nonborrowers, transaction-cost-rationed households live in villages that are further away from formal lenders, and they are less likely to correctly

[11] In Peru, "district" corresponds to the third level of political disaggregation after department and province and is the most disaggregated level for which the Ministry of Agriculture provides historical yield data. Our sample is spread across 12 separate districts.

[12] The questions were framed in reference to a common form of lottery in Peru called a *rifa*, in which a fixed number of individuals contribute a fee into a common pot. A single winner is then randomly drawn. Sample households were asked how much they would be willing to pay for a *rifa* ticket with 10 players, each of whom contributed 100 Soles. Their response, R, indicates the expected return required to make them indifferent between participating or not. Using a second-order approximation, the coefficient of absolute risk aversion can thus be computed as $RA = (10 - R)/0.5(10 - R)^2$.

TABLE 5

DEFINITIONS AND MEANS OF VARIABLES USED IN MULTINOMIAL LOGIT

Variable	Definition	Mean
Wealth	Household wealth excluding farm land (1,000 Soles)	4.22
Labor	Available family labor = Adult male equivalents that do not hold a permanent job.	1.68
Educ	Completed years of education of household head	4.57
Land	Farm size (hectares)	4.19
Title	Proportion of farmland with registered property title	.66
Distance	Distance in public transportation to nearest formal lender (minutes)	26.30
Informed	Equals one if correctly identified the minister of economics	.84
CV	Coefficient of variation of yields in district	.56
RA	Absolute risk aversion of household head	.01
Maxinformal	Maximum transfer the household could receive from family or friends in an emergency (1,000 Soles)	.72

identify the current economics minister. Turning to risk-rationed households, we see that they tend to live in districts with greater background risk and are more risk averse as compared to both unconstrained nonborrowers and transaction-cost-rationed households.

The likely correlations across our different explanatory variables require that we move to a multivariate analysis. The framework we use is the single equation multinomial logit model. Let Y_i be a categorical variable that takes values $0, 1, \ldots, J$ and that represents the observed credit market rationing outcome of household i. Define Y_{ij}^* as the unobserved "propensity" of household i to be in rationing category j:

$$Y_{ij}^* = \beta' X_i + \varepsilon_{ij}, \tag{9}$$

where X_i is a vector of household characteristics, β_j is a vector of parameters associated with the jth category, and ε_{ij} is the unobserved component of the ith household's propensity to be in category j. The observed category is the one with the highest propensity. The probability that household i is in the jth rationing category is thus

$$\Pr(Y_i = j) = \Pr(Y_{ij}^* > Y_{ik}^*), \qquad \forall \ k \neq j. \tag{10}$$

The model is operationalized by assuming that the $J + 1$, ε_{ij} terms are independent and identically distributed with Weibull distribution.

The regressors and their means are summarized in table 5. The first four variables are measures of the household's productive endowments, including farmland, nonfarm wealth, education, and the amount of family labor available to work on the farm. These variables are included to control for the quality of the household's investment opportunities and potential demand for credit. The

TABLE 6
MARGINAL IMPACT OF REGRESSORS ON PROBABILITY OF RATIONING REGIMES

Variable	Price-Rationed Borrower	Price-Rationed Nonborrower	Transaction- Cost Rationed	Risk Rationed	Quantity Rationed
Wealth	.011**	−.002	.000	−.008	.002
	(.004)	(.004)	(.002)	(.005)	(.003)
Labor	.035	−.003	−.025*	−.015	.007
	(.023)	(.020)	(.013)	(.021)	(.010)
Educ	.010*	−.007	−.000	−.005	.002
	(.006)	(.006)	(.003)	(.006)	(.003)
Land	−.012*	.004	−.001	.009**	.000
	(.007)	(.005)	(.003)	(.004)	(.003)
Title	.190**	−.104**	−.067**	.045	−.062**
	(.065)	(.044)	(.018)	(.053)	(.020)
Distance	−.004**	.000	.001	.002**	.001*
	(.001)	(.001)	(.000)	(.001)	(.000)
Informed	.134**	−.056	−.026	.016	−.073*
	(.060)	(.061)	(.036)	(.055)	(.044)
CV	−.977	−.290	−.414	1.316**	.365*
	(.600)	(.485)	(.295)	(.427)	(.217)
RA	−4.016	−5.514**	−1.652	7.158**	4.024*
	(3.313)	(2.781)	(1.351)	(3.730)	(2.421)
Maxinformal	.022	−.012	.008	−.006	−.012
	(.015)	(.020)	(.006)	(.018)	(.016)

Note. Marginal effects are estimated at sample median of regressors. Standard errors are in parentheses.
* Marginal impact is significant at the 10% level.
** Marginal impact is significant at the 5% level.

remaining variables are the correlates of transaction costs, background risk, and risk aversion discussed above.

C. Multinomial Logit Results and Discussion

Table 6 reports the marginal impacts of each regressor on the probability of being observed in each rationing category when the explanatory variables are evaluated at the sample median values. First, consider first transaction-cost rationing. As expected, the probability of transaction-cost rationing is increasing in distance to the nearest lender and decreasing in the household-level information variable, although the impact of these variables is not significantly different from zero. Having a registered land title is associated with a significantly lower probability of transaction-cost rationing. One possible explanation for this result is that eligibility for a land title requires that individuals provide a series of documents, such as the national identity card, utility receipts, and receipts for payment of water rights. Many of these documents are also required by formal lenders, so that households who did not meet the documentation requirements for titling are more likely to say that they did not apply for a loan because providing documents would be too expensive.[13]

[13] One might suspect that households in villages farther from lenders and thus facing higher transaction costs were also less likely to receive title. This spurious correlation would not be picked up by the title variable, however, as we have controlled for distance from lender.

Next consider risk rationing. As anticipated, both an increase in background risk as proxied by the coefficient of variation of district yield and an increase in individual specific risk aversion significantly raise the probability of being risk rationed. Having access to larger potential transfers from family and friends, as expected, decreases the probability of risk rationing; however, the marginal impact is not significantly different from zero.

Finally, consider the quantity-rationing regime. Property title has a strong and significant negative impact on the probability of a household facing a binding supply-side constraint. This is expected as formal lenders in Piura are increasingly requiring borrowers to post real collateral.

Taken together, these results provide evidence that the DEM is capturing meaningful differences across nonborrowing households. The results with respect to the risk-related variables are particularly encouraging. The district-level coefficient of variation and the individual specific risk aversion parameter are strong predictors of risk rationing. These results suggest that the DEM indeed allows the researcher to distinguish individuals whose credit demands are most affected by risk. The results are less informative with respect to transaction-cost rationing. It is not clear, however, whether this reflects an inability of the DEM to effectively detect those households deterred by transaction costs or instead a lack of strong instruments for transaction costs in the multinomial logit regression. We will return to these issues and suggest several options for strengthening the DEM in the final section.

V. The Impacts of Credit Constraints on Agricultural Production in Peru

In this section, we use the Peru data to estimate the impacts of credit constraints on farm production. Before proceeding, a cautionary note is in order. We do not seek here to provide a definitive treatment of the impact of credit constraints. Instead, our primary aim is to illustrate how the direct elicitation approach can be combined with other techniques to generate credible estimates of the impacts of credit constraints. One of the advantages of the approach is that it accounts for the multiple forms of nonprice rationing that, as we argued in Section II, are likely to exist in rural credit markets. Each form, whether emanating from the demand or supply side of the credit market, restricts household participation in the credit market and adversely affects investment. Any evaluation of the performance of rural credit markets should thus account for all forms of nonprice rationing. We demonstrate this by generating two impact estimates; the first considers only quantity-rationed farmers as credit constrained, while the second also includes risk- and transaction-cost-rationed farmers.

Table 7 compares mean productivity levels by rationing mechanism for the

TABLE 7
MEAN FARM PRODUCTIVITY BY RATIONING MECHANISM

Rationing Mechanism	% of Sample	Output per Hectare ($)
Price	51	1,350
Quantity	23	887**
Risk	16	700**
Transaction costs	10	843**

** Statistically different (at the 5% level) from the mean for price-rationed households.

pooled data set. Compared to price-rationed households, the value of production per hectare is significantly lower for quantity-, risk-, and transaction-cost-rationed households, suggesting that each form of nonprice rationing adversely affects farm resource allocation. Failure to consider risk- and transaction-cost rationing would result in a significant underestimate of the frequency of credit constraints. In this example, the underestimation would be 26%, the combined frequency of risk and transaction-cost rationing in the sample. In addition, the low productivity of risk- and transaction-cost-rationed households suggests that, in more aggregate terms, the restrictive definition would also result in a significant underestimation of the efficiency and income loss due to credit constraints. Whether or not we can attribute these impacts to credit constraints per se, however, is not certain since we have not controlled for other factors that affect farm productivity and that may be correlated with households' credit constraint status. This section develops an econometric model that controls for both observed and unobserved determinants of farm productivity and thus allows us to isolate the impact of credit constraints.

A. Econometric Model

As our primary aim is to illustrate the use of information generated by the DEM, we use a relatively simple specification and estimation technique.[14] Consider the following linear specification of farm productivity:

$$y_{it} = \alpha + \beta C_{it} + \gamma Z_{it} + \eta_i + \varepsilon_{it}. \tag{11}$$

The dependent variable, y_{it}, is the per hectare value of farm output for household i in period t. The binary variable C_{it} takes value one if the household is constrained in the formal sector in period t and zero if unconstrained; Z_{it} is a vector of time-varying household and farm characteristics that affect produc-

[14] For a more complex econometric approach using nonexperimental data, see Carter and Olinto (2003), who estimate a switching regression model with semiparametric controls for residual selection (i.e., endogeneity due to time-varying unobservables).

TABLE 8
DEFINITION AND SUMMARY STATISTICS OF VARIABLES INCLUDED IN PRODUCTIVITY ESTIMATION

Variable	Definition	Mean	SD
Y	Revenue per hectare ($)	1,087.59	1,002.64
Land	Farm size (hectares)	4.48	5.48
Liquidity	Saving and credit ($1,000)	1.38	3.60
Adult	No. of adults	4.15	1.96
Dep	(No. of children)/(Household size)	.19	.20
Reginc	No. of adults with salaried job	.13	.38
Herd	Head of cattle	1.58	4.23
Rice	Equals one if cultivates rice, zero otherwise	.53	.50
Cotton	Equals one if cultivates cotton, zero otherwise	.21	.41
Banana	Equals one if cultivates bananas, zero otherwise	.21	.41
Corn	Equals one if cultivates corn, zero otherwise	.35	.48
Time	Equals one if year is 1997, zero otherwise	.5	.5
Durables	Value of durable goods ($1,000)	.53	1.22
T	Proportion of titled land	.58	.69
N	Proportion of neighbors with formal loan	.28	.26

tivity. Included in Z_{it} are the household's endowments of land, liquidity, and labor; the household's dependency ratio; the presence of regular wage earners; the size of the household's cattle herd; and the value of consumer durables and dummy variables indicating the household's crop mix. The definitions, means, and standard deviations of all variables are reported in table 8. The household fixed effect, η_i, captures the impact of time-invariant household characteristics affecting productivity, while α, β, and γ are parameters to be estimated. Finally, ε_{it} is a mean zero error term.

We are primarily interested in β, which gives the impact of being credit constrained on farm productivity. In order to see how the definition of the credit constraint influences β, we estimate equation (10) twice—first using the restrictive definition and then using the comprehensive definition. In estimating β, we face two potential sources of bias. First, the household fixed effect is unobserved, and it is potentially correlated with the other regressors. We estimate equation (10) using first differences and thereby eliminate this potential source of bias. Second, unobserved time-varying factors such as shocks to land quality or health may be correlated with both productivity and the household's credit constraint status.

To address this second potential source of endogeneity, we use an instrumental variable approach. Recall that credit constraints can derive from both the supply side (quantity rationing) and demand side (risk and transaction cost rationing) of the credit market. We thus use two instruments for the household's credit constraint status. The first, T_{it}, is the property title variable from Section IV, defined as the proportion of the household's owned land that has a registered property title. As titled land is the primary form of collateral required by formal

lenders, the probability that a household faces a binding supply-side constraint should be decreasing in T_{it}. Titled land is unlikely to have a direct effect on productivity via enhanced tenure security because nontitled farmers possess alternative documents recognized by local authorities. The primary recipients of title in our sample were *comuneros*, members of Peru's peasant communities. The government's titling program was initiated in peasant communities in 1999 (between the 2 survey years). The percentage of *comuneros* in our sample with a registered title increased from 1% to 39%. The program was universal (i.e., the goal was to title 100% of plots) and costless to *comuneros*. Variation in title status was thus fairly exogenous, depending primarily on the location of the parcel relative to the spatial rollout of the titling program.[15]

The second instrument, N_{it}, is a network variable that measures the proportion of a household's neighbors with a formal loan.[16] A higher fraction of neighbors participating in the formal credit market should increase the information available about loan contracts to potential borrowers and thus is anticipated to decrease the probability that a household is demand-side constrained. Neighbors with formal lending experience can guide potential applicants through the application process, thereby lowering transaction costs. Focus group discussions with farmers in this region also suggest that farmers with no previous borrowing experience tend to overstate the likelihood that formal lenders execute collateral clauses of loan contracts (Guirkinger 2006). Interaction with experienced borrowers may lead to a downward evaluation of contractual risk and thus a reduced likelihood of risk rationing. While we are reasonably comfortable with the titling instrument, we are less comfortable with the network instrument because it may be spatially correlated with unobserved productivity shocks. We return to this concern when we present our results in the next section.

B. Estimation Results and Discussion

The estimation was carried out using two-stage least squares on the first difference of equation (11). As described above, the estimation is carried out twice, once using the comprehensive definition and once using the restricted definition of credit constraint. Table 9 presents the results of the estimations. Column A

---

[15] It is possible, of course, that title status is not completely orthogonal to farm productivity. For example, it is possible that titles were first granted in areas with relatively high-quality (or low-quality) land. Interviews with government officials revealed that the cadastral and administrative process began at one extreme of the community and proceeded sequentially toward the other extreme.
[16] The network variable is constructed using a weighting matrix, where the weights are inversely proportional to the distance between households in the sample. Neighbors are defined as households living within 10 kilometers of the household considered.

TABLE 9
PARAMETER ESTIMATES OF PRODUCTIVITY EQUATIONS

Variable	Restrictive Definition 2 IV (A)	Comprehensive Definition 2 IV (B)	Restrictive Definition 1 IV (C)	Comprehensive Definition 1 IV (D)
C	−682.97*	−684.48**	−677.67**	−696.65**
	(351.17)	(340.51)	(352.8)	(347.09)
Land	−195.75***	−200.62***	−195.64***	−200.95***
	(41.19)	(44.14)	(41.16)	(44.1)
Liquidity	10.44	8.21	10.48	8.09
	(14.22)	(14.17)	(14.23)	(14.26)
Adult	10.65	5.93	10.45	6.3
	(28.21)	(27.5)	(28.11)	(27.05)
Dep	275.56	182.8	274.2	184.29
	(244.86)	(220.77)	(244.36)	(219.83)
Reginc	71.9	81.68	71.64	82.45
	(123.06)	(126.15)	(122.94)	(126.2)
Herd	25.18**	33.17**	25.19**	33.28**
	(11.71)	(11.35)	(11.7)	(11.35)
Rice	518.33***	456.87***	517.88***	456.83***
	(119.43)	(112.89)	(119.52)	(113.05)
Cotton	−259.56***	−216.14**	−260.14***	−214.05**
	(100.4)	(113.26)	(100.1)	(111.04)
Banana	−103.88	−42.65	−103.77	−41.8
	(209.1)	(202.79)	(208.95)	(202.62)
Corn	−44.13	−89.43	−44.98	−88.3
	(96.59)	(85.4)	(96.49)	(85.33)
Durables	49.41	36.84	49.61	36.16
	(34.13)	(40.21)	(34.2)	(41.11)
Time	−455.15***	−357.98***	−453.88***	−359.17***
	(106.72)	(66.36)	(107.43)	(69.64)
F-test IV first stage	5.84	7.07	11.65	12.86
p-value	.003	.001	.001	.000
Hansen J-statistic X^2	.086	.008		
p-value	.769	.931		

Note. Standard errors are in parentheses.
* Significant at the 10% level.
** Significant at the 5% level.
*** Significant at the 1% level.

reports parameter estimates using the restrictive definition, while column B reports the estimates under the comprehensive definition. For the estimations reported in columns A and B, the title and network instruments are jointly significant in the first stage and pass the Hansen J-test of overidentification, suggesting that our instruments are valid in the sense of being strongly correlated with the probability of being constrained and orthogonal to the disturbance term ε_{it}.[17] Although our instruments as a set pass the test for overidentifying

[17] Results of the F-test of joint significance and of the Hansen test are reported in the two last rows of table 9. The null hypothesis of the Hansen test is that the instruments are independent of ε_{it}; failing to reject the null hypothesis therefore suggests that the set of instrument is valid.

restrictions, given the concerns we raised above about the potential endogeneity of the network variable, we also ran the two regressions using only the title variable as an instrument for credit constraint status. These results are reported in columns C and D of table 9. As the differences across the two sets of parameter estimates are minimal, we base the remainder of our discussion using the parameter estimates reported in columns A and B.

Under both definitions, credit constraints have a negative and significant impact on farm productivity. The parameter estimate $\hat{\beta}$ is similar when the comprehensive definition of credit constraints is used instead of the restrictive definition. Under both definitions, relaxing credit constraints would raise the value of production per hectare by just over \$680 on average. As many more households are classified as constrained under the comprehensive definition, the regression results suggest that the overall impact of credit constraints is much larger when the comprehensive definition is used.

These results can be used to generate an estimate of the percentage increase in total value of agricultural production if all credit constraints were relaxed in the region. To do so, we compute Δ, defined as follows:

$$\Delta = \frac{\sum_j [E(y_j|C = 0) * \mathrm{land}_j - E(y_j|C = 1) * \mathrm{land}_j]}{\sum_i \sum_t y_{it} \mathrm{land}_{it}} = \frac{-\hat{\beta} \sum_j \mathrm{land}_j}{\sum_i \sum_t y_{it} \mathrm{land}_{it}}, \quad (12)$$

where $j \in J$ and J is the set of credit-constrained observations in the pooled sample. The numerator gives the predicted change in the total value of production if the credit constraints of households observed to be constrained were relaxed. The denominator gives the total observed value of production for all households in the sample. We find that alleviating credit constraints would raise regional output by 15.1% under the restrictive definition and by 32.6% under the comprehensive definition.[18] In this example, accounting for transaction cost and risk rationing leads to a measure of impact that is over twice as large as that obtained under the restrictive definition. This sharp increase reflects the fact that transaction-cost- and risk-rationed households control 24% of sample land. When they are included in the constrained group, the percentage of land controlled by constrained farmers increases from 20% to 44% of total land in the sample. Finally, we remind the reader that the goal of this analysis is to illustrate how the DEM can be used to generate impact

---

[18] We generated bootstrapped confidence intervals for these estimates by drawing with replacement 1,000 samples from the original data and computing the estimates of the regional impacts for each sample (after estimating the model on each sample). The 95% confidence interval for loss in regional output with the restrictive definition is [14.5%, 15.8%]; with the comprehensive definition it is [31.2%, 34.1%].

estimates. The results are tentative as they depend on strong and unverifiable identification assumptions that, as with the assumptions underlying all empirical work, should be evaluated with a healthy dose of skepticism.

VI. Conclusion

Asymmetric information and enforcement problems can give rise to multiple forms of nonprice rationing in credit markets. Quantity rationing has received the bulk of the attention in the economics literature. Yet transaction-cost rationing and risk rationing are also consequences of lenders' efforts to mitigate information and enforcement problems. Just like quantity-rationed households, transaction-cost- and risk-rationed households have unmet notional demand and find their resource allocation adversely affected by their terms of access to the credit market. We found that neglecting constraints deriving from transaction cost and risk rationing would result in a significant underestimation of both the frequency and impacts of credit constraints in rural Peru.

Empirical evaluation of the relative importance of the different forms of nonprice rationing is crucial for the design of effective policy. Examples of policies that may relax the binding supply-side constraint facing quantity-rationed households include land titling and property rights reforms that make households' assets more valuable to lenders as collateral and investment in credit bureaus or other institutions that enhance the flow of information so that lenders can more easily identify high-quality borrowers. These policies, however, would do little to relax the constraints facing transaction-cost- and risk-rationed households. Instead, policies that streamline legal processes for registering collateral and enforcing loan contracts or that provide a means of insuring households against production, price, or health risk would be more appropriate.

We outlined a survey methodology to determine whether or not a household is credit constrained and, if so, to identify the rationing mechanism at play. This classification relies on two stages of questions that elicit different types of information. The first stage collects information regarding the respondent's actions and the outcomes of those actions: Were any loan applications made? To which lenders? Were they approved? An additional set of questions is required to determine the constraint status of nonapplicants. These questions are designed to understand the reasons that these respondents did not seek a loan, as well as the actions they would take in counterfactual situations, such as whether or not they would borrow if offered a loan. While these subjective questions are second best in the sense that they do not rely on observed actions of respondents, we presented evidence suggesting that they can provide a reliable method of separating constrained versus unconstrained nonborrowers.

We conclude by suggesting two directions of methodological improvement for tackling the challenging issue of separating constrained from unconstrained nonparticipants in the credit market. The first offers refinements to the DEM, while the second builds on the randomization methodology discussed in the introduction.

A. Fine Tuning of Nonborrower Perceptions Module

Consider again question 7 in figure 2, which asks individuals who believe they qualify for a loan to explain why they did not apply. One means of strengthening the DEM is to follow up question 7 (and 9) with two additional lines of questioning. If the respondent indicates that transaction costs are the primary reason for not applying, the enumerator would then ask the respondent to identify the specific sources of the transaction costs and to estimate the associated monetary and time costs. The second follow-up question would be an additional counterfactual: "Would you seek a loan if these transaction costs (but not the interest rate) were eliminated?" Similar questions would be asked to apparent risk-rationed individuals, who would first be asked to describe what actions the lender would take if the loan was not repaid. They would then be asked if they would seek a loan if the default consequences (i.e., the contractual risk) were eliminated. Responses to these two follow-up questions would allow for more accurate classification of the respondent's rationing mechanism.[19] For example, consider a respondent who gave "fear of losing land" as the reason for not applying in question 7. If this respondent then indicated that he would still not seek a loan even if the risk of losing land were eliminated, the researcher would conclude that the lack of demand is due primarily to a lack of a profitable investment project and not to contractual risk. This respondent would then be classified as price rationed (unconstrained) instead of risk rationed.

A second refinement, still within the spirit of the DEM, that would help distinguish constrained from unconstrained nonborrowers is to ask all nonborrowers what they would do with a grant of a given size.[20] Theory suggests that non-price-rationed individuals have a higher shadow value of liquidity and so should be more likely to say that they would invest the money in their farm or business than price-rationed individuals. Again consider a farmer who is apparently risk rationed based on question 7. We could more confidently classify this farmer as risk rationed if he then states that he would use the entire grant to purchase fertilizer than if he instead states that he would put

---

[19] Identifying specific components and sizes of transaction costs can also help inform policy.
[20] Paulson and Townsend (2004) follow this strategy in a microenterprise survey in Thailand.

the money in his savings account. Conditional on this latter response, the researcher may reclassify the farmer as price rationed.

B. Randomized Field Experiments

Field randomizations, by exogenously varying the control variable of interest in a real-life environment, offer an attractive method of testing hypotheses relating to the extent and underlying causes of credit constraints. In the introduction to this article, we mentioned several innovative research projects using randomizations. The randomizations of both Karlan and Zinman (2009) and de Mel et al. (2008) relax a supply-side constraint and thus focus on the extent and impact of quantity rationing.

Randomizations may also be used to examine the prevalence and impact of demand-side constraints. Gine and Yang (2007) have taken an innovative step in this direction. In their work in Malawi, they randomized the offer of a production loan linked with a rainfall insurance contract to maize farmers. The control group was instead offered only the credit contract. In contrast to expectations, they found that the availability of insurance negatively had a negative impact on loan demand. This research is also illustrative of the challenges of field randomizations. In particular, great care must be taken to ensure that the exogenous treatment provided in the field coincides with the theoretically intended treatment. This is especially challenging when the treatment involves modifying contractual risk. Gine and Yang suggest, for example, that their surprising results may be due to the "high cognitive cost of evaluating insurance" (4). In other words, the authors suspect that farmers did not perceive the insurance made available in the way that the authors designed.

We have argued that demand-side constraints are likely to be important barriers to agricultural development, especially where insurance markets are weak. Unfortunately, transaction cost and especially risk rationing have received little attention in academic and policy circles. Identifying and distinguishing the multiple forms that credit constraints take is thus an important although challenging task. The direct elicitation methodology offers one approach to do so. As we hope is clear, we do not advocate the DEM to the exclusion of other empirical methodologies. Instead, we view it as a complement to other methods including randomizations as well as others we have not discussed here such as qualitative case studies. Ideally, researchers will "circle the wagons" around this critical question of the performance of rural credit markets by bringing to bear multiple and complementary methods so that policy can move forward in the most informed way possible.

References

Aghion, Philippe, and Patrick Bolton. 1997. "A Theory of Trickle-Down Growth and Development." *Review of Economic Studies* 64, no. 2:151–72.

Banerjee, Abhijit, and Esther Duflo. 2004. "Do Firms Want to Borrow More? Testing Credit Constraints Using a Directed Lending Program." CEPR Discussion Paper no. 4681, Centre for Economic Policy Research, London.

Banerjee, Abhijit, and Andrew Newman. 1993. "Occupational Choice and the Process of Development." *Journal of Political Economy* 101, no. 2:274–98.

Barham, Bradford, Stephen Boucher, and Michael Carter. 1996. "Credit Constraints, Credit Unions, and Small-Scale Producers in Guatemala." *World Development* 24, no. 5:792–805.

Bell, Clive, T. N. Srinivasan, and Christopher Udry. 1997. "Rationing, Spillover, and Interlinking in Credit Markets: The Case of Rural Punjab." *Oxford Economic Papers* 49:557–85.

Bester, Helmut. 1987. "The Role of Collateral in Credit Markets with Imperfect Information." *European Economic Review* 31, no. 4:887–99.

Boucher, Stephen, Bradford Barham, and Michael Carter. 2005. "The Impact of Market-Friendly Reforms on Credit and Land Markets in Honduras and Nicaragua." *World Development* 33, no. 1:107–28.

Boucher, Stephen, Michael Carter, and Catherine Guirkinger. 2008. "Risk Rationing and Wealth Effects in Credit Markets: Theory and Implications for Agricultural Development." *American Journal of Agricultural Economics* 90, no. 2: 409–23.

Boucher, Stephen, and Catherine Guirkinger. 2007. "Risk, Wealth, and Sectoral Choice in Rural Credit Markets." *American Journal of Agricultural Economics* 89, no. 4:991–1004.

Carter, Michael, and Christopher Barrett. 2006. "The Economics of Poverty Traps and Persistent Poverty: An Asset-Based Approach." *Journal of Development Studies* 42, no. 2:178–99.

Carter, Michael, and Pedro Olinto. 2003. "Getting Institutions Right for Whom? Credit Constraints and the Impact of Property Rights on the Quantity and Composition of Investment." *American Journal of Agricultural Economics* 85, no. 1:173–86.

Chung, Inuk. 1995. "Market Choice and Effective Demand for Credit: The Roles of Borrower Transaction Costs and Rationing Constraints." *Journal of Economic Development* 20, no. 2:23–44.

de Mel, Suresh, David McKenzie, and Christopher Woodruff. 2008. "Returns to Capital in Microenterprises: Evidence from a Field Experiment." *Quarterly Journal of Economics* 123, no. 4:1329–72.

Diagne, Aliou, Manfred Zeller, and Manohar Sharma. 2001. "Access to Credit and Its Impact on Welfare in Malawi." IFPRI Research Report no. 116, International Food Policy Research Institute, Washington, DC.

Eswaran, Mukesh, and Ashok Kotwal. 1989. "Credit as Insurance in Agrarian Economies." *Journal of Development Economics* 31, no. 1:37–53.

———. 1990. "Implications of Credit Constraints for Risk Behavior in Less Developed Economies." *Oxford Economic Papers* 42:473–82.

Feder, Gershon, Lawrence Lau, Justin Lin, and Xiaopeng Luo. 1990. "The Relation

between Credit and Productivity in Chinese Agriculture: A Model of Disequilibrium." *American Journal of Agricultural Economics* 72, no. 5:1151–57.

Fletschner, Diana. 2008. "Women's Access to Credit: Does It Matter for Household Efficiency?" *American Journal of Agricultural Economics* 90, no. 3:669–83.

Foltz, Jeremy. 2004. "Credit Market Access and Profitability in Tunisian Agriculture." *Agricultural Economics* 30, no. 3:229–40.

Gine, Xavier, and Dean Yang. 2007. "Insurance, Credit, and Technology Adoption: Field Experimental Evidence from Malawi." World Bank Policy Research Working Paper no. 4425, World Bank, Washington, DC.

Guirkinger, Catherine. 2006. *Risk and the Structure of Rural Credit Market.* PhD thesis, University of California, Davis.

Guirkinger, Catherine, and Stephen Boucher. 2008. "Credit Constraints and Productivity in Peruvian Agriculture." *Agricultural Economics* 39, no. 3:295–308.

Guirkinger, Catherine, and Carolina Trivelli. 2006. "Limitado financiamiento formal para la pequeña agricultura: Solo un problema de falta de oferta?" [Limited formal credit for small-holder agriculture: Is it just a problem of lack of supply?] *Debate Agrario* 40–41:31–60.

Hoff, Karla, and Joseph Stiglitz. 1990. "Imperfect Information and Rural Credit Markets: Puzzles and Policy Perspectives." *World Bank Economic Review* 5:235–50.

Jappelli, Tullio. 1990. "Who Is Credit Constrained in the U.S. Economy?" *Quarterly Journal of Economics* 105, no. 1:219–34.

Karlan, Dean, and Jonathan Zinman. 2009. "Expanding Credit Access: Using Randomized Supply Decisions to Estimate the Impacts." *Review of Financial Studies* (forthcoming).

Kochar, Anjini. 1997. "An Empirical Investigation of Rationing Constraints in Rural Credit Markets in India." *Journal of Development Economics* 53, no. 2:339–71.

Mushinski, David. 1999. "An Analysis of Loan Offer Functions of Banks and Credit Unions in Guatemala." *Journal of Development Studies* 36, no. 2:88–112.

Paulson, Anna, and Robert Townsend. 2004. "Entrepreneurship and Financial Constraints in Thailand." *Journal of Corporate Finance* 10 (March): 229–62.

Petrick, Martin. 2004. "A Microeconometric Analysis of Credit Rationing in the Polish Farm Sector." *European Review of Agricultural Economics* 31, no. 1:23–47.

Udry, Christopher, and Jonathan Conning. 2005. "Rural Financial Markets." In *Handbook of Agricultural Economics*, vol. 3, ed. Robert Evenson, Prabbhu Pingali, and Paul Schultz. Amsterdam: Elsevier Science.

Zimmerman, Frederick, and Michael Carter. 2003. "Asset Smoothing, Consumption Smoothing and the Reproduction of Inequality under Risk and Subsistence Constraints." *Journal of Development Economics* 71, no. 2:233–60.