Dynamics of Investment for Market-Oriented Farmers in Chile

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Abstract

Using panel data from a survey conducted in 2006 and 2008 of 177 market-oriented farmers in central Chile, we investigate investment under imperfect capital markets. Specifically we determine the impact of formal credit constraints on fixed investment. By controlling for endogeneity problems, we find credit constraints to have a significant negative impact on fixed investment. In addition, a time trend is significant, which we understand as evidence of the impact of the global financial crisis of 2007.

Keywords: Investment, credit constraint, medium-scale farmers, Chile

1 Introduction

An investment can be broadly defined as an outlay of cash in exchange for expected future cash returns (Barry and Robison, 2001: p.84), and it is possible to distinguish between capital investments and financial investments. The former is the purchase of capital goods (such as a machine or buildings) to produce goods for future consumption. The latter is the purchase of assets (such as securities, bank deposits) with a primary view to their financial return, either as income or capital gain; this form represents a means of saving. In this study we focus on the capital (or real) investment.

Market-oriented farmers need more capital for three main reasons: to invest in new technologies, to meet the requirements of international regulations on quality and food safety, and to obtain scale and scope economies. All these investments play an important role in increasing the productivity and efficiency of a firm.

However, to invest in certain goods carry costs which farmers have to face. Changes in capital stock are associated with additional costs of machinery, administration and planning the capital expansion. All these costs are assumed by farmers if they expect higher prices and productivity. However, when expectations are uncertain, as in a global financial crisis period, these uncertainties lead to lower investments by risk-averse farmers.

The objective of this paper is to explore the factors that influence the decision to invest in fixed capital for farmers in Chile. Specifically we focus on the impact of formal credit constraints on investment decisions. In doing so we also try to detect the time trend in a investment model. The panel data structure of our data base allows us to test differences in farmers' probability to invest during the years of our study, which were strongly influenced by the global financial crisis of 2007. Increasing volatility and uncertainty may cause higher interest rates in the financial market and may influence investment decisions (Demir, 2009).

Then, irreversible fixed investment in the farming sector may be negatively affected by the uncertainty of the future.

Our contribution is two-fold: First, we empirically estimate the impact of credit constraints on investment in a developing country context, using a direct measure for capital constraints. Although investment studies under capital market imperfections are extensive, most of this literature is based on the idea that investment is only sensitive to internal funds if there are imperfect capital markets. Empirically these studies, first introduced by Fazzari et al. (1988), have been conducted by dividing the study sample according to an a priori measure of financing constraints, after which a variable that proxies for internal funds is compared in both subsamples. In some studies the variable that proxies for internal funds is cash flow.

Some authors, however, question the relevance of the use of cash flow as a measure of financial constraints. Kaplan and Zingales (1997) argue that investment-cash flow sensitivities do not provide useful evidence about the presence of financial constraints. Demir (2009) shows that the availability of internal funds may be a necessary but not a sufficient condition for financing a real investment project. In addition, an a priori classification of financing constraints is problematic since the threshold used to classify firms in different groups is set arbitrarily (Hoang and Antoncic, 2003). Some exceptions to the previous measurement of credit constraint methods are Petrick (2004) and Feder (2001) who propose to proxy the credit constraint status by using results of a direct survey. In their survey farmers were directly asked about their perception of credit constraints. Both studies, conducted in Poland and China respectively, found that credit constraints negatively affect investment.

A completely different approach is used by Rajan and Zingales (1998) in trying to determine the impact of financial market imperfections on investment and growth. Specifically their study uses the interaction between industry`s dependence on external funds and financial market development in a country as indicator of financial market imperfections in the investment model. Their study suggests that financial development may play a particularly beneficial role in investment in new firms. If new firms are the source of new ideas, financial development can enhance innovation, and this, in turn, enhances growth in indirect ways. Although their approach partly solves the problems associated with the investment cash-flow estimates, it still does suffer from not using a direct measure for capital constraints.

To estimate investment decisions this study directly measures credit constraints based on a direct elicitation approach (Guirkinger, 2008; Boucher et al., 2009) where the randomly selected farmers were asked about the perception of their formal credit constraint status. Although one drawback of directly asking responders about their borrowing experience is that such an approach relies only on an individual's subjective assessment of his situation, it is better than relying on an arbitrarily chosen variable that may not distinguish between credit-constrained and unconstrained farmers.

Second, we address the potential endogeneity problems of a credit constraint variable by using a discrete switching endogenous model (Miranda & Rabe-Hesketh, 2006). The endogeneity problems arise in a credit-market context because several unobserved characteristics may at the same time affect investments and the probability of becoming credit constrained. For instance, some farmers who are unknown to banks but who are very innovative may have a higher probability of being credit constrained, but they also may have more investments. In this case, not controlling for this "unobserved" factor will lead to an underestimation of the effect of credit constraints because the positive effect of innovation skills will also be picked up by the credit constraint variable which will, in and of itself, counteract the negative effect of credit constraints. On the other hand, farmers with poor entrepreneurial ability (an unobservable factor) are both less likely to invest in fixed capital and more likely to be limited in their access to credit. In this case, not controlling for endogeneity will lead to an overestimation of the effect of credit constraints.

The rest of the paper is organized as follows. Section 2 provides an overview of empirical investment models applied in the literature. Section 3 presents the empirical approach used in this study based on an endogenous switching dummy variable model with state dependence. Section 4 describes the context of our study together with the data collection. Sections 5 shows the results of two different econometric strategies on an estimated investment model with potential endogeneity problems. Finally section 6 concludes and discusses the main findings.

2 Theoretical framework

In this section we explain the most relevant studies about how to empirically estimate investment under capital market imperfections[1]. Under the assumption of perfect capital markets with firms having equal and unlimited access to invest at an exogenously determined cost, financing decisions or the capital structure of a firm should not have any impact on private investment decisions (Modigliani and Merton, 1958). However, under imperfect capital markets related to asymmetric information problems, the Modigliani and Miller proposition no longer holds and liquidity variables, such as cash flow, has a significant effect on investment decisions.

The literature has been developed in several ways to empirically estimate the investment model under imperfect capital markets. Three basic types of models have been applied: the *q* model of investment (also called the flexible accelerator model or Tobin's *q* investment model), the structural investment model (also called the stochastic Euler equation) and the reduced form model.

[1] For a complete survey on investment equations we referred to Lensink, R., H. Bo and E. Sterken (2001) *Investment, capital market imperfections, and uncertainty: Theory and empirical results* (Cheltenham, UK: Edward Elgar)., and Petrick, M. (2005) Empirical measurement of credit rationing in agriculture: a methodological survey. *Agricultural Economics*, 33(2), pp. 191-203.

First, the q model of investment proposed by Tobin (1969) states that all fluctuations in investment are related to the q indicator, which is the ratio of the market value of installed capital to the replacement cost of installed capital. An increase in Tobin's q should have a positive effect on investment. In this equation, variables that may say something about financial constraint are added to the basic reduced-form equation of investment. Based on the idea that investments are sensitive to internal funds in imperfect capital markets, it is common to include cash flow as a measure of internal sources.

On the other hand, since most firms (including farms) are likely to be financially constrained in some sense, the investment-cash flow sensitivity indicator would be positive for almost all firms. To get around this problem it is common to divide the sample into two groups where each may be more or less likely to be credit constrained and to compare the investment-cash flow sensitivity indicator for both subsamples. A greater investment-cash flow sensitivity coefficient is seen as an indicator of more severe capital restrictions. This approach is popularized by Fazzary, Hubbard and Petersen (Fazzari, Hubbard et al., 1988) and is widely used in literature with different splitting criteria. A sample-splitting criteria that have been considered in literature include dividend payout ratios (Fazzari, Hubbard et al., 1988), firm size, age or growth (Devereux and Schiantarelli, 1990), the firm credit rating (Whited, 1992) the dispersion in the firm's share ownership (Schaller, 1993); whether the firm is affiliated to a larger corporate grouping (Hoshi et al., 1991; Hermes and Lensink, 1998); and the firm has a relationship with a particular bank (Elston, 1993).

However some criticism of this approach has arisen mainly because of the use of investment cash flow sensitivity as a measure of financial constraints and the *a priori* classification of firms into different groups. Kaplan and Zingles (1997) criticize Fazzary, Hubbard and Petersen's approach by pointing out that while constrained firms should be sensitive to internal cash flow and unconstrained firms may not need to be, it is not necessarily true that the magnitude of the sensibility increases with the degree of financing constraints. In particular, their results indicate that a higher sensitivity of investment to cash flow is not associated with more financially constrained firms.

In addition, two problems may arise from *a priori* classification of firms into different groups. Firstly, the threshold used to classify firms in different groups is set arbitrarily, and secondly, although it might be possible to identify constrained firms, it is quite often impossible to identify the years during which a firm is constrained. This makes it impossible to differentiate between firm-specific effects on investment and the effects of financing constraints (Kaplan and Zingales, 1997; Hoang and Antoncic, 2003).

The second approach to estimating an investment equation is the structural investment model approach, also called the Euler model of investment (Bond and Meghir, 1994). The idea of the structural investment model is to maximize the firm's present value subject to capital accumulation and external borrowing constraints. With this optimization problem the optimal path for investment is derived, which yields an empirical Euler equation under the null hypothesis of no financial constraints. Like the previous model, the sample needs to be divided into two groups—credit constrained farmers and unconstrained farmers—in order to test the Euler equation. This Euler equation has a lagged investment variable which is most likely correlated with current investment. Then in estimating this equation, state dependency needs to be considered[2]. This approach does not necessarily need an explicit investment equation and, consequently, it is not necessary to estimate a Tobin's *q*, avoiding problems related to the measurement of Tobin's *q*. Some example of this approach are Whited (1992), Bond and Meghir, (1994), Hubbard (1995) Demir (2009).

[2] For lagged variables in a continuous model see Arellano and Bond Arellano, M. and S. Bond (1991) Some tests of specification for panel data: Monte carlo evidence and an application to employment equations. *The Review of Economic Studies*, 58(2), pp. 277-297. and for discrete lagged variables see Woodridge Wooldridge, J. M. (2005) Simple solutions to the initial conditions problem in dynamic, nonlinear panel data models with unobserved heterogeneity. *Journal of Applied Econometrics*, 20(1), pp. 39-54..

However, the structural models of investment that have been proposed to date have not been successful in characterizing a dynamics process, possibly because they have neglected the potential importance of endogeneity and measurement errors in average q (Bond and Van Reenen, 2007). An intermediate possibility is to rely on dynamic econometric specifications that are not explicitly derived as optimal firm behavior, but address questions without fully specifying the nature of investment equations. A favorable interpretation of such reduced-form models is that they represent an empirical approximation to some complex underlying process that was generated by the data. However, a less favorable interpretation is that they compound the parameters adjustment process with parameters of the expectation-formation process in determining investment, causing identification problems. Fortunately, some possible solutions to the identification problems can be found. Models like this have been introduced into the investment literature by Bean (1981), Bond et al. (2003) and Petrick (2004).

The model considered in this paper follows the approach that use a reduce-form of dynamic investment decision model. These reduced-form investment models have the following implications (Petrick, 2004): First, limited access to credit causes a lagged adjustment of capital stocks to a steady state. Second, optimal investment is dependent on the equity formation of the household in terms of the profit retention or savings, or more generally, on the availability of collateral. Finally, investment and credit demand are thus neither separable from consumption decisions nor independent of the equity position of the farm. These implications are followed in the empirical model used in this study.

In addition, three characteristics distinguish the model used in this stydy. First, we use a discrete instead of a continuous variable for investment in order to empirically estimate the impact of credit constraints on the probability of farmers to invest. Our interest is to study the variables that impact the decision whether to invest in fixed capital with two-year data set. In addition, for a continuous model of investment, at least a three-year data set is needed (Arellano and Bond, 1991). Thus, we need to limit our analysis to that covered in a dynamic investment decision model because we have less than three years of data. Second, we include a credit constraint variable, which allows us to test our primary question, the impact of credit constraint on investment. Instead of using a proxy for a credit constraint, we use a directly collected variable for a credit constraint which include a broader definition of credit constraints (Boucher, Guirkinger et al., 2009).

Finally, we include a lagged investment variable to retain the dynamic process of investment.

3 Empirical approach

To deal with the dynamic estimation of a discrete variable for investment and a possible endogenous credit constraint variable, this section sets out a statistical model that permits identification of state dependence, taking into account the potentially confounding effect of unobserved individual heterogeneity (Wooldridge, 2005).

Let us label with y^*_{it} the latent continuous variable representing investment decision for farmer i (i=1,…, N) at time t (t=1,…,T). The dynamic investment decision model is thus defined by the following equations:

$$y^*_{it} = x'_{it}\beta + \gamma y_{it-1} + \alpha_i + \varepsilon_{it} \qquad \textbf{(1)}$$

With

$$y_{it} = 1 \text{ if } y^*_{it} > 0$$

$$y_{it} = 0 \text{ if } y^*_{it} \leq 0$$

Where x_{it} represents the vector of explanatory variables affecting the investment decision and y_{it-1} is the lagged investment decision variable. The coefficients γ and β are the parameters to be estimated. The term α_i captures unobserved heterogeneity and accounts for all time invariant unobserved individual characteristics that influence investment decision. This will include, for example, entrepreneurial abilities or capacities. The null hypothesis of no state dependence implies that $\gamma = 0$. The parameter γ should be interpreted as the average effect over the time period considered.

The model is dynamic in the sense that it allows the unobservable farmer's probability to invest to be a function of previous farmer investment. Defining a state as a realization of a stochastic process, we may think of state dependence in term of the actual investment pattern being dependent on the state of investment decision that was revealed for the previous investment of the same farmer.

However, equation (1) has two methodical problems related with its estimation: initial conditions and an endogeneity problem.

The initial condition problem arises in our estimation because α_i is an individual-specific term, which appears in every equation for the same individual over time. In particular, it will appear in the equation for y_{it} and also in the equation for y_{it-1}. Therefore in the equation for y_{it} the regressor y_{it-1} is necessary correlated with the error component α_i. This will cause endogeneity problems of y_{it-1} and, if unaddressed, will tend to produce a bias in the coefficient estimate of y_{it-1}, which provides an estimate of state dependence. This is called "the initial condition problem". Intuitively, the problem is that the model describes a dynamic process, and we need to allow for it to start. The probability to invest in the current year depend on whether the farmer invested in the year before and the probability to invest in the year before depends on whether the farmer invested two years before, and so on. However information on whether the farmer invests in the first year is most of the time missing.

Fortunately, Wooldridge (2005) proposed a simple strategy to address this problem in dynamic nonlinear panel data models with unobserved heterogeneity. This paper suggests to model the distribution of the unobserved effect conditional on the initial value and any exogenous explanatory variables. On using this suggestion to estimate probit, ordered probit, tobit and poisson regressions, an auxiliary distribution can be chosen that leads to straightforward estimation, namely the introduction of the same time-invariant initial observation as a regressor in the equation for y_{it}. With this simple shortcut, partial effect on mean responses, averaged across the distribution of observables, are identified. Thus, equation (5.1) can be re-written as:

$$y_{it} = x_{it}'\beta + \gamma y_{it-1} + \varphi y_{i0} + \alpha_i + \varepsilon_{it} \qquad \textbf{(2)}$$

With

$y_{it} = 1$ if $y_{it}^* > 0$

$y_{it} = 0$ if $y_{it}^* = 0$

Where y_{i0} is the time-invariant initial condition of investment decision and φ is the regressor to be estimated. The term φ will also indicate the correlation between the initial and current investment decision.

In determining the effect of a credit constraint on probability to invest, another major problem is the possible endogeneity of a credit constraint in the sense that credit constraint status is correlated with unobservable heterogeneity. For instance, farmers with poor entrepreneurial ability (unobservable heterogeneity) are both less likely to invest in fixed capital and more likely to be limited in their access to credit.

To get around this problem, an endogenous switching binary variable for a dynamic investment decision model in panel data can be written as a system of equations for the substantive equation (investment equation) and the endogenous equation (credit constraint). By treating the responses as repeated measurements nested within individuals, the endogenous switching model fits neatly into a multilevel framework (Skrondal and Rabe-Hesketh, 2004). We keep the same specification of probability to invest (y_{it}) for farmer *i*

(i=1,…, N) at time t (t=1,…,T). The binary variable CC^{*}_{2it} simply indicates presence or absence of a credit constraint. The joint model is thus defined by the following equations:

$$y^{*}_{1it} = x'_{it}\beta + \gamma y_{it-1} + \varphi y_{i0} + \phi CC + \varepsilon_{1it} \qquad \textbf{(3)}$$

With

$y_{it} = 1$ if $y^{*}_{it} > 0$

$y_{it} = 0$ if $y^{*}_{it} = 0$

And

$$CC^{*}_{2it} = z'_{it}\gamma + \varepsilon_{2it} \qquad \textbf{(4)}$$

With

$CC_{2it} = 1$ if $CC^{*}_{2it} > 0$

$CC_{2it} = 0$ if $CC^{*}_{2it} = 0$

Where x_{it} and z_{it} represent the vectors of explanatory variables affecting the decision to invest and credit constraint status, respectively. The coefficients γ and β are the parameters to be estimated.

To take into account the panel data structure and impose dependence between both residuals, the residuals in equations (3) and (4) are decomposed as $\varepsilon_{1it} = \alpha_{1i} + \lambda\delta_{it} + \mu_{1it}$ and $\varepsilon_{2it} = \alpha_{2i} + \delta_{it} + \mu_{2it}$. These three terms capture unobservable heterogeneity: α_{1i} and α_{2i} are the random intercepts for each individual normally distributed with zero mean and variance $\sigma^2_{\alpha 1}$ and $\sigma^2_{\alpha 2}$, respectively, and covariance $\sigma^2_{\alpha 1;\alpha 2}$; δ_{it} is a shared random effect to induce dependence between substantive and endogenous equation by the factor λ , normally distributed with zero mean and variance $\sigma^2_{\delta_{it}}$; μ_{1it} and μ_{2it} represent the random error specific for output production and credit constraint status, respectively, and are assumed to be normally distributed and independent of x_{it} and z_{it} with zero mean and variance $\sigma^2_{\mu_{1it}}$ and

$\sigma^2_{\mu_{2it}}$, respectively. Therefore, $Var(\varepsilon_{1it}) = \sigma^2_{\alpha_{1i}} + \lambda^2\sigma^2_{\delta_{it}} + \sigma^2_{\mu_{1it}}$, $Var(\varepsilon_{2it}) = \sigma^2_{\alpha_{2i}} + \sigma^2_{\delta_{it}} + \sigma^2_{\mu_{2it}}$ and $Cov(\varepsilon_{1it}, \varepsilon_{2it}) = \lambda\sigma^2_{\delta_{it}} + \sigma^2_{\alpha_{1i};\alpha_{2i}}$. Then equations (3) and (4) are now;

$$y^*_{1it} = x'_{it}\beta + \gamma y_{it-1} + \varphi y_{i0} + \phi CC + \alpha_{1i} + \lambda\delta_{it} + \mu_{1it} \quad \textbf{(5)}$$

With

$y_{it} = 1$ if $y^*_{it} > 0$

$y_{it} = 0$ if $y^*_{it} = 0$

And

$$CC^*_{2it} = z'_{it}\gamma + \alpha_{2i} + \delta_{it} + \mu_{2it} \quad \textbf{(6)}^{3}$$

With

$CC_{2it} = 1$ if $CC^*_{2it} > 0$

$CC_{2it} = 0$ if $CC^*_{2it} = 0$

4 Data and context

The study area comprises the regions V, VI and Metropolitana, situated in the central part of Chile. The counties selected from this area are home to Chile’s most important fresh fruit and vegetable production: Los Andes, San Felipe (V Region), Rancagua (VI Region), San Bernardo, Buin, Paine, and Melipilla (Region Metropolitana). Agricultural land in this area is mainly irrigated and a well-developed system of reservoirs and irrigation and drainage canals greatly reduce risk associated with supply and timing of water. The predominant agricultural activity is fruit production, with the major crops being table grapes, kiwi fruit, nectarines, apples, apricots, pears and avocados. Much of Chile's fruit production in this area is exported during the northern winter to the USA, Canada and Europe. These areas also produce and export large quantities of wine, forest products, seeds, fresh flowers and processed fruits and vegetables.

[3] See Appendix 2 for details about identification problem.

4.1 Formal financial sector

Chile's banking system has changed significantly over the last 30 years. During the period 1974–83, the Chilean government almost completely liberalised the financial sector by abolishing virtually all financial controls. However, the liberalisation destabilised the economy, forcing the government to step in and rescue the failing banks in 1983 (Fry, 1994). The government also introduced a supervisory system for the financial sector (*Superintendencia de Bancos e Instituciones Financieras*), which is still in place. This regulatory framework is intended to reduce bank failures and helps to ensure an adequate level of bank solvency (Fuentes and Vergara, 2003).

The Chilean banking sector is now one of the most developed and promising of the region. This sector contains 20 active commercial banks[4]: 12 foreign-owned, 7 Chilean-owned and one state-owned bank (SBIF, 2009). During the last 20 years, the financial sector has experienced an outstanding growth. In 2001 the ratio of credit allocated by deposit money banks to GDP was 63.6%, which is the highest figure in Latin America. The second country in the region in this respect is Brazil (Gallego and Loayza, 2004; Hernandez and Parro, 2004).

[4] Excluding branches of foreign banks that are mainly devoted to cash and portfolio management activities

Table 1: Loan portfolio in agriculture in Chile, 2003-2007 and number of bank offices, 2007

	Loan portfolio in Agriculture (million US$)					**Number of bank offices**	
BANK	**2003**	**2004**	**2005**	**2006**	**2007**	**Rural Central Area**	**Total country**
Scotiabank Sud Americano	18.463	67.759	91.480	10.459	130.964	15	40
Banco Chile	662.517	792.148	726.838	768.575	979.733	55	280
Banco Itaú Chile	9.045	18.709	30.277	77.872	139.359	15	40
Banco Estado	144.670	111.588	105.163	188.010	280.774	60	320
Banco Bice	88.515	107.813	142.144	212.088	289.132	15	30
Banco Del Desarrollo	142.329	178.037	219.992	263.895	297.410	21	40
Banco Bilbao, Vizcaya	12.559	12.889	177.923	244.526	775.137	15	40
Corpbanca	147.909	252.376	318.454	338.493	398.999	25	190
BCI	30.848	413.673	476.453	64.709	822.778	31	210
Santander Santiago Chile	488.622	583.684	789.898	1163.259	1243.409	40	250
TOTAL	**1745.474**	**2538.676**	**3078.622**	**3331.885**	**5357.697**	**299**	**1930**

Source: SBIF (2009)

Table 1 shows that the primary agricultural credit provider in Chile is Banco Santander (foreign bank), followed by Banco Chile (Chilean bank), Banco Bilbao (foreign bank), and Banco BCI (Chilean bank). These loans are characterised by being heavily collateralised and made available mainly to medium and large farmers. While bank officials in Chile do sometimes visit farm borrowers, these visits usually tend to take place prior to loan approval and with the aim of appraising the value of collateral assets, not to monitor the project during execution (Conning 2005). Whilst all the commercial banks have offices across the country, branches are mainly concentrated in the central area.

Generally speaking, a formal loan application has to go through the following process in rural financial markets in Chile: Prospective borrowers have to submit a loan application at the local bank branch, together with a business plan describing the purpose of the loan. This loan application has to be accompanied by a description and official proof of collateral. A local loan officer visits the prospective borrower, evaluates the business plan, and decides whether to extend the loan. However as pointed out by Karcz (1998) and Petrick (2004), the reliability or reputation of a borrower as indicated by previous punctual repayment of loans as at least as important for obtaining credit as is the sufficient availability of collateral. It is important to note that in Chile all banks have access to a financial recording system (DICOM), which records previous formal loan performance including defaults and delayed payments and thus acts as a reputation score.

In general, default rates in Chile's financial system are quite small (4%) and the delayed payments are in order of 8%.

4.2 The survey

In this study we use a broader definition of rationing mechanism, as introduced by Boucher et al. (Boucher, Guirkinger et al., 2009). Their definition not only consider quantity rationing, as do most of the studies (Feder et al., 1990; Jaffee and Stiglitz, 1990; Kochar, 1997; Petrick, 2004), but also risk and transaction-cost rationing. As explained in Boucher et al. (2009), transaction-cost rationed farmers are those who have a positive demand for credit, but no effective demand because of high transaction cost. Similarly, risk-rationed farmers are those who prefer a lower return on a secure activity more than a risky activity. Thus, in addition to the typical demographic and production aspects, we include in our survey core questions dealing with credit behaviour, including information on loan sources, loan applications, credit contracts, credit from suppliers, traders, and collateral[5]. These questions are used to classify the farmers into one of the following formal sector rationing categories:

a) Unconstrained borrowers. The household is unaffected by a credit limit from the formal financial sector and obtains the desired amount.

b) Unconstrained non-borrowers. The household is unaffected by a credit limit, but does not borrow in the formal sector because it has no project that requires a formal loan.

[5]Appendix 1 provides the questions applied in the survey.

c) Quantity rationing. Households face a binding credit limit because their loan application is rejected, do not seek a formal loan because the loan requirements cannot be met, or obtain a loan for a lower amount than requested.

d) Transaction-cost rationing. Households do not face a binding credit limit, but do not seek a formal loan because the transaction costs associated with the loan application are too high.

e) Risk rationing. Households do not face a binding credit limit, but do not seek a formal loan because the risk implied by available credit contracts is too high.

The data we use derives from a survey of a random sample of farms in central Chile, recorded by the Natural Resources Information Center (CIREN). We only consider market-oriented farmers, that is, farmers who manage a minimum of 10 productive hectares and sell their crops to a third party (market). We exclude subsistence, non-cultivated, and recreational farms, because formal financial institutions do not target these farmers, and because market-oriented farmers are the main players in the Chilean agricultural sector. We choose 10 hectares as the minimum productive area because it represents the minimum size required to support a family in Chile.

The survey was carried out in 2006 and 2008 and contains data on the 2005–2006 and 2007–2008 seasons, respectively[6]. In the first wave of the survey, data consisted of a random sample of 200 farms located in seven counties in the central region of Chile. During the second wave, we collected information from 205 farmers, 177 of which were in the first wave. The survey instrument was repeated with slight differences. Table 2 provides descriptive characteristics of the farms taken in the sample.

[6] The survey can be obtained on request.

Table 2:Sample statistics of surveyed farms (n=354, pooled sample)

Variable	Definition	Mean	Standard deviation
HECTARES	Farm size (hectares)	76.80	111.22
ASSETS NO HA	Total assets (machinery and facilities) net from hectares (millions of Chilean$)	243.58	554.28
INV	Binary dummy with a 1 if the farmer decided to invest in the current season	0.53	0.50
LAGGED INV	Binary dummy with a 1 if the farmer decided to invest in the past season	0.69	0.46
INI INV	Binary dummy with a 1 if the farmer decided to invest in the season 2003-2004	0.72	0.45
CREDIT CONSTRAINT	Binary dummy with a 1 if farmer is either quantity, risk or transaction-cost constraint	0.15	0.35
INSURANCE	Binary dummy with a 1 if the firm use insurance instruments, 0 otherwise	0.03	0.18
CLUSTER	Number of relationships that a firm has with export and/or input supplier firms.	1.42	0.81
YEAR ADM	Years farming (years)	22.90	12.34
NO PROGRAM	1 if the firm do not have neither employees-training program nor GAP certification, 0 otherwise	0.23	0.42
ALMOND	1 if the farm has Almond as a main production, 0 otherwise	0.04	0.21
AVOCADO	1 if the farm has Avocado as a main production, 0 otherwise	0.07	0.26
WINE GRAPE	1 if the farm has Wine Grape as a main production, 0 otherwise	0.06	0.24

Notes: 1,000 Chilean $= 1.58 US

Table 3 shows the investment activity by farmers in different years. Investment refers to the gross investment made during the current and previous calendar year because investment occurs across a longer period than one year (e.g., plantation and irrigation systems). The 2006 survey shows investments from 2005 to 2006, while the survey made in 2008 collected information on investments from 2007 to 2008. In addition, during the first round in 2006, farmers were required to recall investments made from 2003 to 2004. As illustrated in Table 3, investment decreased from a total of $39 million in 2003 and 2004 to

$15 million in 2007 and 2008. This can be explained by the uncertainty caused by the financial crisis in 2008. It is commonly known that in uncertain economic environments, entrepreneurs invest less (Demir, 2009). In addition, only 40% of our sample invested in 2007 and 2008, in contrast to the 70% who decided to invest in 2003 and 2004.

Table 3: Investment behavior by farmers, 2003-2008

	2003-2004	2005-2006	2007-2008
Investment (million Ch$) [1]	38.74	38.08	14.83
Percentage of farmers investing	72	66	40
Number of farmers	177	177	177

[1] Investment in million Chilean pesos; 1,000 Chilean$= 1.58 US$

In the context of investment decision models, firms will be financially constrained if external sources of finance (for example, from new share issues or borrowing) are assumed to be more expensive than internal sources of finance (for, example, from retained earnings) Bond (2007). Under this context, the three categories of credit constraints (quantity, risk and transaction cost) introduced by Boucher (2009) may be relevant in determining the impact of credit constraint on investment decision. In all three categories of credit constraints, farmers have a demand for credit but they are constrained in accessing credit by a limited capacity to provide collateral, high transaction costs of the credit contract, or a high level of risk associated with the credit contract. In other words, all three types of credit constraints can lead to an imperfect or even inexistent credit market and, thus, both sources of finance, internal and external, are not perfect substitute.

Table 4 shows that on average 53% of farmers in our sample invested (pooled sample), with higher investment activities for borrowers (59%) and transaction-cost rationed farmers (67%). Quantity-rationed farmers are those who invested less with only 47% investing in fixed capital. On the other hand, unconstrained borrowers and nonborrowers seemed to be wealthier farmers with larger holdings than quantity- and risk-rationed farmers.

From our results it seems that investment decision is driven by credit status, with the exception of transaction-cost rationed credit constraint. However, farm size and endowment seems to be correlated with credit status as well. This may cause endogeneity problems in trying to explain the investment decision process.

We also observe in Table 4 that the number of farmers who were transaction-cost and risk-rationed was very low (6 and 10, respectively). We therefore merge the two categories in the remainder of this paper.

Table 4: Investments by farmers classified according to credit constraint status, pooled sample 2006 and 2008

Credit Constraint Status	**Investment per farm**		**Land size**	**Assets**	**Total sample**
Unconstrained	**Volume (million Ch$)**	**Proportion of farmers investing (%)**	**(ha)**	**Volume (million Ch$)**	***Sample size***
Borrowers	36.6	59	82	1336	118
Non-borrowers	21.2	49	82	1463	184
Sub-total	27.2	53	82	1413	302
Formal sector credit constrained					
Quantity rationed	12.7	47	41	836	36
Transaction cost rationed	55.1	67	83	863	6
Risk rationed	34.7	50	47	840	10
Sub-total	**21.9**	**50**	**47**	840	**52**
Total	**26.4**	**53**	**77**	**1329**	**354**

5 Are investments influenced by a credit constraint?

We now present the estimation results for the dynamic investment decision model without considering endogeneity problems for credit constraint variable, presented in section 3 in equation (2). As our model is dynamic, we include a two-period lagged investment decision as a variable to capture state dependence. We also include the initial investment decision as a regressor in order to avoid initial condition problems (Wooldridge, 2005).

In addition, we include some control variables in the model, including variables that proxy for credit constraints, existing capital stock, for observable farm(er)-specific effects and for a time trend. The credit constraint variable indicate presence or absence of credit constraint, considering as credit constraint all three forms of formal credit rationing: quantity, risk and transaction cost (see section 4.2). The proxy for existing capital stock is the amount of assets, measured as the valued total of farm assets including land, machinery and facilities (in logs). All assets are priced using market prices. The effect of the amount of assets on the probability to invest depends on the size of the capital stock or farm size. A negative sign of the amount of assets implies that large farms have less probability to invest, meaning that the farm size decrease over time, whereas a positive sign implies an increasing farm size.

The proxies for observable farm(er)-specific characteristics are years of farming experience (in logs), farmer participation in a training or certification program, and farm activity. From prior observations the expectation was that the experience of the household head could have a positive impact on the probability to invest because skilled farmers tend to invest more (Petrick, 2004). Production characteristics of farm activity are captured by variables related to specialization in a particular fruit or horticulture product. The expectation is that specialization in a higher-value crop such as almonds or avocados tends to result in a higher probability to invest. Finally, we expect a negative sign for the time trend. This is because the 2008 global financial crisis affected investment decisions.

Table 5 presents the results of the dynamic investment model if we deny endogeneity problems. We first estimate the model without considering the lagged investment and the initial condition variables (model 1). Then, in model 2 these variables are included. Finally, model 3 keeps all statistically significant variables at a level of 20%[7], with two exceptions. The initial investment variable is maintained to avoid the initial condition problems explained in section 2, and the credit constraint dummy variable. We include this variable to be able to compare this result with the later analysis.

Table 5 shows that the total amount of assets and time trend are statistically significant in all models. This preliminary result means that having a larger number of assets has a

[7] We chose 20% as a level of significance to avoid any omitted variable problems in non-lineal estimations. In this case omitted variables could cause biased estimators.

positive effect on the probability to invest, suggesting that on average farm size in Chile is growing. However, we will return to this analysis in the next table where endogeneity problems are considered. In addition, the time trend indicates that there is a strong negative relation between the time trend and investment. The financial crisis that affected the world in 2008 may be the explanation of this result. This crisis may have affected the investment decisions of farmers who decided to postpone investment in no urgent assets to later years when they hoped to find a less uncertain environment. Finally, Table 5 shows that the credit constraint dummy variable is insignificant in all specifications, suggesting as primary result that rural financial market are efficient in Chile.

Since the random intercept is shared between each observation for the same individual, intraclass correlation explains the proportion of the total variance that is explained by individuals. In our case the proportion of the total variance explained by individuals is very low in all models. This is because explaining variables, specially the time trend and the amount of assets, capture most of the variance explained by individuals.

Although Table 5 shows that the level of state dependence is not significant, we can see differences in the unobservable heterogeneity between both models. In model 1, 7.5% of the unexplained variation is captured by the individual effect. In contrast, the unobservable heterogeneity practically disappears in model 2. This may be due to the fact that we have explicitly taken into account the presence of state dependence by means of the lagged investment variable.

Table 5: Parameter estimates from the dynamic investment decision model

	Model 1	Model 2	Model 3
LAGGED INVESTMENT		0.261	0.268
		[0.154]	[0.140]
INITIAL INVESTMENT		0.115	0.111
		[0.542]	[0.555]
LN (YEAR FARM+1)	0.0909	0.0809	
	[0.411]	[0.446]	
NO_PROGRAMME	0.0144	0.0394	
	[0.935]	[0.815]	
AVOCADO	-0.0846	-0.0689	
	[0.762]	[0.797]	
ALMOND	-0.458	-0.539	-0.520
	[0.220]	[0.134]	[0.141]
LN[ASSETS]	0.157**	0.139*	0.128*
	[0.045]	[0.060]	[0.078]
TIME TREND	-0.749***	-0.711***	-0.705***
	[0.000]	[0.000]	[0.000]
CREDIT CONSTRAINT	-0.0164	-0.0443	-0.0488
	[0.939]	[0.829]	[0.809]
Constant	-0.102	-0.272	0.0420
	[0.882]	[0.681]	[0.936]
N	354	354	354
Log likelihood	-228.5	-226.2	-226.6
Individual	177	177	177
Wald Test	28.12***	35.09***	34.53***
Intraclass correlation	0.076	0.000	0.000

Notes: *p*-values in brackets; *, ** and * indicate 1%, 5% and 10% levels of significance respectively; all models are estimated using probit models; Wald test for the significance of all regressors but the constant; Continuous variables such as assets and years farming are measured in logarithms to avoid possible heterogeneity problems.**

We now move to determine to what extent formal credit constraints affect the investment decision-making process for market-oriented farmers in central Chile taking into account endogeneity problems. Because there is likely a dependence between a credit constraint and investment, we need to prevent a possible endogenous credit constraint variable within the panel data structure. In addition, because investment is a dynamic decision process we need to take state dependence into account.

As we saw in section 3, to estimate investment equation (5) and endogenous switching credit constraint equation (6), we use a multilevel approach (Rabe-Hesketh et al., 2005). We start using model 3 investment specification for investment equation. For the credit constraint switching variable we include variables that do not appear in the investment equation and that correlate with credit constraint status. These variables are the number of clusters that the firm belongs to, whether or not the farmer uses insurance, farmer participation in a training and certification program, and variables related to farm activity such as avocado and wine-grapes. Although the endogenous switching model is formally identified through its functional form (Wilde, 2000), we keep some variables as exclusion restriction in the endogenous switching equation in order to maintain an economic identification (Miranda and Rabe-Hesketh, 2006).

Because a model with an exogenous switching variable is nested within the endogenous switching model, the test for the endogeneity of credit constraint *(CC)* in equation (5) can be performed on the basis of a simple likelihood ratio test for correlation between investment decision and credit constraint equation at the observation level ($\rho = 0$).

The econometric model will enable to distinguish some alternative hypotheses regarding the effect of credit constraint categories on the probability to invest for market-oriented farmers in Chile. In particular, we will be able to distinguish four different situations:

1) The correlation coefficient ρ is not statistically different from zero, and the coefficient on credit constraint status in the probability to invest equation is statistically significant. In this case the credit constraint status is exogenous with respect to probability to invest and its effect is causal.

2) The correlation coefficient ρ is statistically significant while the coefficient for credit constraints in the probability to invest equation is not. In this case the credit constraint status is endogenous with respect to probability to invest, and the correlation between *CC* and probability to invest is driven by unobserved heterogeneity.

3) Both the correlation coefficient ρ and the coefficient on CC in the probability to invest equation are significant. In this case, although CC is endogenous with probability to invest, it also has a causal impact on probability to invest.

4) The correlation coefficient and the coefficient on CC in the probability to invest equation are both insignificant. In this case our analysis will not support any of the hypotheses outlined in the literature review.

We estimate two models: The panel data investment model considers a dummy endogenous variable for credit constraint, with (model 4) and without (model 5) considering the state dependence (Table 6). The parameter estimates show two outstanding results in both models: a significant positive correlation between unobservable heterogeneity in the investment and credit constraint equations, and a significant negative effect of credit constraints on investment decisions.

First, the likelihood ratio test (LR Test) which compares the exogenous against the endogenous model is statistically different from zero at the 5% level in both models. This evidence is in favor of endogenous credit constraint. Even if the LR test for endogenous bias has low power, endogeneity of credit constraint is confirmed as we see differences in the parameter estimates from model 3 (Table 5) and model 5 (Table 6). The endogenous adjustment does cause a significant change in two of the output estimators: assets and credit constraint. Thus, neglecting the potential endogeneity of credit constraint variable on estimating farmer's probability to invest may result in a serious bias. In this case the bias changes the coefficient from insignificant to negatively significant[8].

Second, the estimation results provide evidence that credit constraints have a causal impact on investment, and that a credit constraint condition is endogenous with respect to

[8] Note that the correlation between the error in the probability to invest equation and credit constraint equation is positive and statically significant at 1%. Hence, unobservable heterogeneity in investment equation is positive correlated with the one in credit constraint. In this context, the positive ρ can be associated to the exclusion of the other relevant variables. This can be explained by, for instance, farmers with highly- return risky project. These farmers are more likely to be credit constraint and more willing to invest.

investment. In other words, when credit constraint treatment is randomly distributed among market-oriented farmers, the effect of credit constraints on investment decision is significantly negative.

As we can see from model 4 in Table 6, the coefficient of lagged investment fails to be statistically significant, suggesting no state dependence in the probability to invest equation. This result is confirmed by the Bayesian Information Criterion (BIC) and Akaike's Information Criterion (AIC), which favors model 5.

Again the unobservable heterogeneity from individuals is very low. Only 7.1% (model 4) and 14.5% (model 5) of the unexplained variation is captured by the individual effect. The difference between the unobservable heterogeneity from individuals in models 4 and 5 may be due to the fact that we have explicitly taken into account the presence of state dependence by means of the lagged investment in model 4.

Another variable that remains significant is the time trend. This variable is believed to measure the effect of the financial crisis on investment. On the other hand, the significance of the variable on the total amount of assets changed compared with the previous analysis. Taking endogeneity into account, the coefficient for total assets is not statistically significant.

Other than in the previous section, the variable assets (in logs) is not statistically significant. Its coefficient goes from positive and significant in the probit model to insignificant in the endogenous switching model. This result indicates that unobservable factors that influence both credit constraint status and probability to invest also affect assets. Removing this effect by considering endogeneity problems of the credit constraint variable shows that the value of assets does not affect the probability to invest. Thus, it is incorrect to state that large farmers invest more.

The coefficients for the variables included in the credit constraint model for models 4 and 5 show that they are strong predictors of credit-constrained farmers (Table 6).

Table 6: Parameter estimates from the dynamic investment decision model with an endogenous switching binary variable

Investment equation	Model 4	Model 5
LAGGED INVESTMENT	0.250	
	[0.196]	
INITIAL INVESTMENT	0.140	
	[0.464]	
ALMOND	-0.246	-0.193
	[0.482]	[0.604]
LN[ASSETS]	0.046	0.069
	[0.531]	[0.399]
TIME TREND	-0.685***	-0.698***
	[0.000]	[0.000]
CREDIT CONSTRAINT	-1.051***	-0.912**
	[0.000]	[0.042]
Constant	0.670	0.798
	[0.213]	[0.164]
ENDOGENOUS CREDIT CONSTRAINT MODEL		
LAGGED INVESTMENT	0.329	
	[0.243]	
INITIAL INVESTMENT	-0.241	
	[0.396]	
ALMOND	0.850*	0,828*
	[0.061]	[0,061]
LN[ASSETS]	-0.436***	-0,429***
	[0.000]	[0,000]
TIME TREND	-0.116	-0,130
	[0.453]	[0,409]
CLUSTER	0.049	0,060
	[0.664]	[0,595]
INSURANCE	2.009***	1,988***
	[0.000]	[0,000]
NO_PROGRAMME	0.224	0,243
	[0.172]	[0,143]
AVOCADO	0.835***	0,783**
	[0.007]	[0,010]
WINE GRAPE	0.953**	0,876**
	[0.011]	[0,018]
Constant	1.463**	1,495**
	[0.049]	[0,045]
Random Effect		
Observation level		
$Var\left(\lambda\delta_{it} + \mu_{1it}\right)$	6.098	1.680163
	[0.645]	[0.379]
$Var\left(\delta_{it} + \mu_{2it}\right)$	2	2
$\rho\ \left(\alpha_{1i} + \lambda\delta_{it} + \mu_{1it}; \alpha_{2i} + \delta_{it} + \mu_{2it}\right)$	0.647***	0.450
	[0.000]	[0.232]

Individual level		
$\sigma^2_{\alpha_{1i}}$	0.462	0.284
	[0.712]	[0.579]
$\sigma^2_{\alpha_{2i}}$	2.120*	2.128*
	[0.090]	[0.089]
$\sigma_{\alpha_{1i}\alpha_{2i}}$	0.990	0.748
	[0.482]	[0.198]
CORR ($\alpha_{1i}\alpha_{2i}$)	1.000	0.963
	[0.000]***	[0.063]*
Intraclass correlation	0.0705	0.1446
Observations	354	354
Individuals	177	177
Log likelihood	-339.632	-342.696
LR Test	3.756*	4.586**
Wald-test	198.45***	189.85***
AIC	723.26	721.39
BIC	823.63	803.51

Notes: *p*-values in brackets; *, ** and * indicate 1%, 5% and 10% levels of significance respectively; both models are estimated by maximum likelihood with 12 quadrature points, adding extra quadrature points did not produce important changes in coefficients and/or standards errors; $\sigma^2_{\alpha_{1i}}$ and $\sigma^2_{\alpha_{1i}}$ refer to the unexplained variance at the individual level for the investment model and the endogenous variable equations respectively; Likelihood ratio test (LR test) compares the exogenous (H_0) with the endogenous model (H_a) and Wald test for the significance of all regressors but the constant; BIC and AIC stand for Bayesian Information Criterion and Akaike's Information Criterion, respectively; The continuous asset variable is measured in logarithms to avoid possible heterogeneity problems.**

Since model 5 is preferred over model 4, the analysis continues by retaining the model 5 estimations reported in Table 6. Thus, Table 7 shows the odds ratios of model 5 on the probability to invest for the two variables we focus on: credit constraint and time trend. Comparing farmers with and without a constraint, with all other variables unchanged, the odds of investment are 2.5 times as high for farmers who do not face a credit constraint compared to farmers who do.

Table 7: Odds ratios for investment equation

Variable	**Odds ratios**	**Standard error**	**95% CI**	
Restricted	2.49	1.12	1.03	5.99
Time trend	2.01	0.26	1.55	2.60

To better understand the effect of a credit constraint on investment, we need to explore the potential difference between constrained and unconstrained farmers for different levels of assets. To do so, we plot an unconstrained farmer's predicted probability to invest as a function of an extended range of values of total assets (in logs), and compare the results with constrained ones. The outcome can be seen in Figure 1. The range of total assets (in logs) actually observed in the data lies approximately between the two vertical lines.

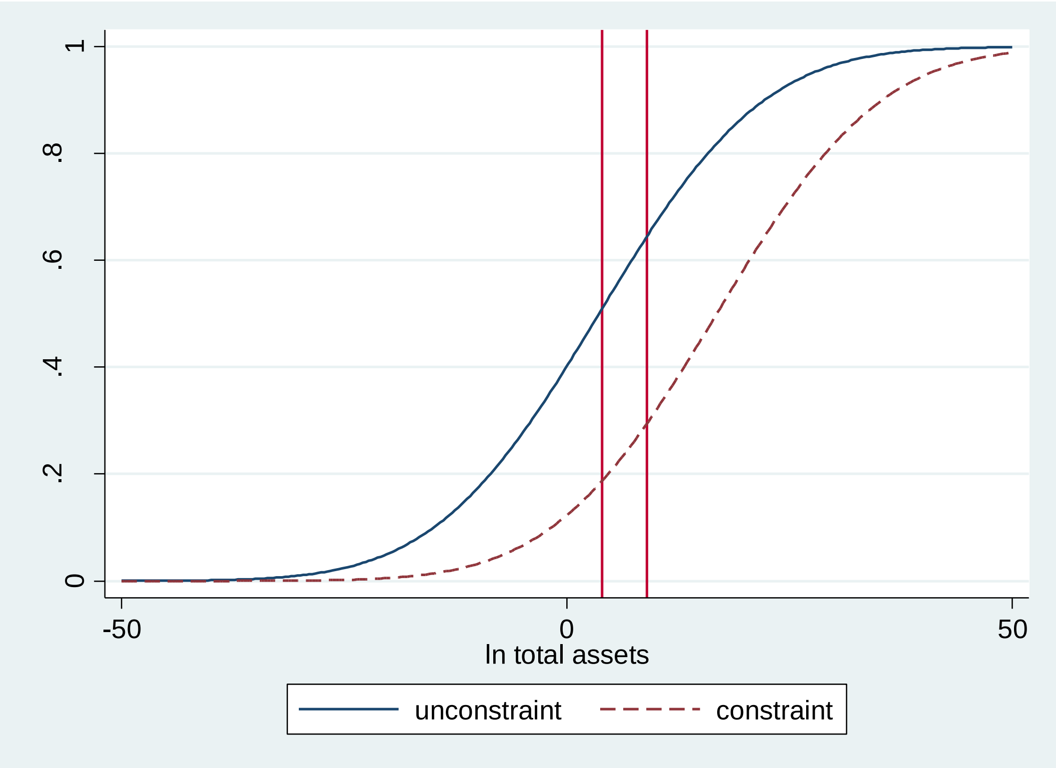

Figure 1: Predicted probabilities by total asset

As expected, the probability to invest increases with a farmer’s wealth. As was shown for the odds rations, the probability to invest for unconstrained farmers is about 2.5 times more than for constrained farmers in the same range of total assets.

Next, comparing farmers’ probability to invest in 2006 to 2008 shown in Table 7 with all other variables remaining the same, the odds of investment are 2.0 times as high for farmers who invested in 2006 compared to farmers who did so in 2008.

6 Discussion

The present work estimates the impact of credit constraint on investment for market-oriented farmers in central Chile. Specifically we estimate a dynamic investment model that takes into account endogenous problems arising from credit constraint variables. The results show that credit constraint is an endogenous variable in determining investment decision. This means that if we estimate investment without taking into account the endogenous determination of credit constraint, we would have biased estimators. Second, it can be assumed that there is not state dependence in the investment equation.

In our study, investment is observed to depend on credit constraint status. It can be interpreted as evidence of imperfect capital markets because constrained farmers, most of them quantity rationed, cannot separate investment and financing decisions. Based on an endogenous switching modeling framework, unconstrained farmers invest more than 2.5 times that of credit constrained farmers in Chile. Although not tested in this paper, this situation can be explained because the only providers of long-term credit are commercial banks for whom lending in the long term is more risky. In addition, agricultural projects can be complex, making their assessment difficult. Variation in market price and weather conditions and foreign exchange fluctuations make farming projects often more uncertain than other projects. Under these circumstances. banks can be hesitant to extend credit to agricultural activities.

This study also reveals the negative impact of time trend on investment decisions. In our sample, roughly 70% of the farmers invested in fixed capital before the 2007 financial crisis. By contrast, 40% of them made investments during 2007-2008. We hypothesize that this may be an effect of the impact of the global financial crisis of 2007.

A few policy recommendations can be derived from our findings. As providing credit for long-term investment is risky for banks under asymmetric information, more information is needed about the creditworthiness of farmers. Policies to improve information about the position of farmers in the credit market is therefore needed. For instance, for farmers it would be important to have well audited balance sheets and income statements to document their reputation as an entrepreneur. In this way farmers can assure banks of the quality of their farming projects as investments and obtain better lending conditions. In addition, other mechanisms to improve information in rural financial markets would be for banks to have risk evaluation departments specialized in agricultural projects. Bank officers well-trained in assessing agro-projects may help in discriminating between good and bad projects. Finally, other instruments need to be explored to avoid asymmetric information like co-signed long-term credit by business cluster member; venture capital to provide financial capital to early-stage, high potential projects; or insurance to control the risk derived from output and prices uncertainties.

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Appendix 1

Direct elicitation method

The following qualitative questions are included in the questionnaire to collect information on different sources of credit rationing.

Question 1

Did you receive a loan in the past three years from a formal credit institution?

If so, we asked several questions with respect to the debt contract characteristics, such as the loan amount, the interest rate, and the loan period. In order to identify quantity rationing, we also asked whether the firm had received the desired amount. In addition, we asked whether the firm had received a loan from another financial institution, or if it would like to receive a loan from another credit institution. This information allowed us to identify cross constraints from different types of formal credit institutions.

If the answer to question 1 was no, we continued with question 2

Question 2

Did you apply for a loan in the past three years?

If so, we asked why the credit institution decided to reject the application.

If the answer to question 2 was no, we continued with question 3.

Question 3

If you had applied, would a formal credit institution have accepted your application?

If so, we asked why he/she did not apply for a loan. Table A1 provides possible answers and the associated rationing category.

If the answer to question 3 was no, we continued with question 4.

Question 4

If you were certain that a commercial bank would approve you application, would you apply?

If the answer was yes, the firm was classified as quantity-constrained.

If the answer was no, we asked why they would not apply for a loan. Again Table A1 shows possible answers and the rationing category associated.

Table A1: Common answers to qualitative questions

Answers	Associated question	Constraint Status
I received the desired loan from formal lenders in the past three years.	Question 1	Unconstrained (Borrowers)
I do not need a loan.	Question 3, 4	Unconstrained (Nonborrowers)
Interest rate is too high.	Question 3, 4	
Farming does not give me enough to repay a debt.	Question 3, 4	
I received a loan from formal lenders in the past three years, but not the desired amount.	Question 1	Constrained (Quantity Rationed)
I applied for a loan in the past three years but my application was rejected.	Question 2	
I did not apply for a loan because I did not think the formal institution would accept my application.	Question 4	
I did not want to risk my land.	Question 3, 4	
I did not want to be worried/ I was afraid.	Question 3, 4	Constrained (Risk Rationed)
Formal lenders are too strict; they are not as flexible as informal ones.	Question 3, 4	
Formal lenders do not offer refinancing.	Question 3, 4	
The bank branch was too far away.	Question 3, 4	Constrained (Transaction-cost Rationed)
Banks require too much paper work associated with application.	Question 3, 4	

Appendix 2

Identification alternative for endogenous switching model

In the system of equations (5) and (6) there are six variance-covariance parameters, $(\sigma^2_{\alpha_{1i}}, \sigma^2_{\alpha_{2i}}, \sigma^2_{\mu_{1it}}, \sigma^2_{\mu_{2it}}, \sigma^2_{\delta_{it}}, \lambda)$. However, there are only three quantities to estimate: the variance of α_{1i} and α_{2i} identified through the intraclass correlation in the substantive and endogenous model respectively; and the correlation between the total residual of the two equations (ρ).

Therefore, it is necessary to impose three restrictions. Two restrictions directly comes from the binary nature of the substantive and endogenous equation, so $\sigma^2_{\mu_{1it}}$ and $\sigma^2_{\mu_{2it}}$ are implicitly fixed to a value determined in the model estimated in both equations (here we use the probit model for the investment decision and endogenous credit constraint equations, then $\sigma^2_{\mu_{2it}} = \sigma^2_{\mu_{2it}} = 1$). The third restriction needed for identification must be stated explicitly: here we fix the factor variance to one ($\sigma^2_{\delta_{it}} = 1$). For discussions and alternatives restrictions see Skrondal and Rabe-Hesketh, (2004).

Thus the covariance matrix of the residual is given by:

$$\sum = \begin{pmatrix} \sigma^2_{\alpha_{1i}} + \lambda^2 + 1 & \lambda + \sigma_{\alpha_{1i};\alpha_{2i}} \\ \lambda + \sigma_{\alpha_{1i};\alpha_{2i}} & \sigma^2_{\alpha_{2i}} + 2 \end{pmatrix}$$

And the correlation is

$$\rho = \frac{\lambda + \sigma_{\alpha_{1i};\alpha_{2i}}}{\sqrt{(\sigma^2_{\alpha_{1i}} + \lambda^2 + 1)(\sigma^2_{\alpha_{2i}} + 2)}}$$

The estimation of ρ will be relevant in our model, because it gives statistical evidence of endogenous bias in our model.

The estimation of this model is by maximum likelihood, with the likelihood function evaluated by the adaptative quadrature numerical technique shown by Rabe-Hesketh et al.

(2005). to be superior to standard quadrature methods, particularly where the number of cross-sectional observations is large and/or the intraclass correlation is high. Maximization of the likelihood function over the set of parameters is achieved by the Newton-Ramhson algorithm.