Impact of Access to Credit on Farm Productivity of Fruit and Vegetable Growers in Chile

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Abstract

The objective of this paper is to analyze the factors that determine productivity of fruit and vegetable growers in central Chile, focusing especially on the effect of short-term credit on farm productivity for market-oriented farmers. We explicitly test for possible selection bias using a panel data set from a survey conducted in 2006 and 2008 with 177 farmers. Our results indicate that short-term credit does not have an impact on farm productivity, while other factors as education and the type of activity do. This results suggest that other providers of credit, such as informal credit institutions, may relax short-term credit constraints in rural financial markets in Chile.

1 Introduction

It is frequently argued in economic studies that rural development should be accompanied by agricultural credit reforms. After the financial structural adjustment of the 1980s which adversely affected the intricate system of public agencies that provide farmers with access to land, credit, insurance, and inputs, farmer organizations in developing countries started demanding an institutional reconstruction of parts of the agriculture support system such as rural development banks (World Bank, 2007). They claim that financial crises aggravated the lack of financial services, even for market-oriented farmers.

Rural development and, in particular, farm productivity, can be influenced by several factors; one is access to credit. Access to credit may affect farm productivity because farmers facing binding capital constraints would tend to use lower levels of inputs in their production activities compared to those not constrained (Feder et al., 1989; Petrick, 2004). Improved access to credit may therefore facilitate optimal input use and have a major impact on productivity. Thus, access to credit allows farmers to satisfy their cash needs induced by the agricultural production cycle and consumption requirements.

Other factors such as the pre-existing household resource endowment, its demographic characteristics, and the conditions of the surrounding physical, social and economic environment are significant factors in determining household income. Thus, farm productivity may be constrained because of other factors far removed from credit availability, and reform of other input markets may have a larger impact on farm income, and hence productivity.

The aim of this paper is to analyze the factors that determine farm productivity in central Chile, focusing especially on the effect of short-term credit. Determining whether or not this variable is significant may help to provide evidence for the impact of credit on farm productivity. Most of the literature has found credit constraint to have a negative impact on farm investment (Carter and Olinto, 2003; Petrick, 2004), farm output (Feder et al., 1990;

Petrick, 2004) farm profit (Carter, 1989; Foltz, 2004; Fletschner et al., 2010) and farm productivity (Guirkinger and Boucher, 2008). In contrast, Kochar (1997) found credit to have no effect on efficiency. We hypothesize that, unlike most of the related studies and popular opinion in Chile, in a liberalized financial environment such as Chile's, credit availability is not an important variable in explaining farm productivity.

However, assessment of the expected productivity gain caused by credit availability is not trivial because the effect of credit is likely to differ between liquidity constrained and unconstrained credit farmers. This means that the marginal effect of credit may actually be zero for borrowers for whom liquidity is not a binding constraint. When liquidity is a binding constraint, the amount and combination of inputs used by a farmer will deviate from their notional optimal level (the levels that would have been utilized if liquidity were not binding constraint). The marginal contribution of credit is therefore to bring input levels closer to optimal levels, thereby increasing output (Feder, Lau et al., 1990). Thus, measuring the difference of credit impact on unconstrained and constrained farmers must consider sample selection bias.

The contribution of this study is twofold. First, we empirically test the impact of credit on farm productivity in central Chile, one of the most competitive and deregulated markets in Latin America. In deregulated financial markets the expectations are that by removing state influence from financial markets, private actors would take over the financial market, reducing their costs, improving their quality, and eliminating favoritism to well-connected groups. Although the financial sector in Chile is not completely deregulated and a financial supervisory system does exist, this regulation attempts to reduce bank failures and helps to ensure an adequate level of bank solvency.

In addition, farmers in Chile can count on a well-spread network of informal lenders, namely input supplier and export firms. Informal lenders provide short-term credit usually payable at harvest with almost no requirements in collateral. Because informal lenders tend to rely less on collateral and more on monitoring to enforce repayments, informal loans became the dominant mode of finance by the mid 1990s (Foster and Valdes, 2006). An active informal sector may relax credit constrains that farmers face in the formal sector. Indeed, if the informal sector is a good substitute of an imperfect formal sector, then we would expect to find little differences in productivity of farmers that are constrained versus those who are unconstrained in the formal sector (Guirkinger and Boucher, 2008).

Secondly, this study utilizes a broad definition of credit constraints (Guirkinger, 2008; Guirkinger and Boucher, 2008; Boucher et al., 2009; Fletschner, Guirkinger et al., 2010) to explain the influence of credit availability on farm productivity of credit-constrained farmers in Chile. We include in our sample not only those farmers limited in their access to credit by banks, but also farmers who chose not to borrow as a result of high transaction costs or risk aversion. Moreover, we test not only for possible selection bias from credit-constrained farmers, but also for individual unobserved heterogeneity.

This paper is organized as follows: Section 2 provides a literature review on the credit constraint impact on farm productivity; section 3 presents the data collection process and the surveyed sample; section 4 describes the empirical approach used in this study; section 5 discusses the results; and finally, section 6 summarizes the findings and discusses policy options.

2 Credit constraint and its impact on productivity

The most popular definition of a credit constraint comes from the seminal paper of Stiglitz and Weiss (1981). Under their definition certain individuals obtain loans while apparently identical individuals, who are willing to borrow at precisely the same terms, do not. Because lenders may take on risky project applications only at high interest rates, they refuse to raise the interest rate to eliminate excess demand and, consequently, may ration their supply for credit. This type of credit constraint is called quantity rationing (Guirkinger, 2008; Guirkinger and Boucher, 2008; Boucher, Guirkinger et al., 2009; Fletschner, Guirkinger et al., 2010), pure credit rationing (Jaffee and Stiglitz, 1990), or simply credit rationing (Feder, Lau et al., 1990; Kochar, 1997; Petrick, 2004). A quantity constraint is thus a supply-side credit restriction.

Several recent studies, however, have introduced two other forms of credit constraint (Guirkinger, 2008; Guirkinger and Boucher, 2008; Boucher, Guirkinger et al., 2009; Fletschner, Guirkinger et al., 2010). First, farmers may not seek a formal loan because the transaction costs associated with the loan application are too high. This may be the result of screening mechanisms that lenders use to guard against adverse selection and moral hazard problems. While these actions may help lenders to avoid granting loans to undesirable clients and may provide borrowers with incentives to avoid undesirable actions, they also pose significant monetary and time costs for borrowers. This type of credit constraint is called transaction-cost rationing.

Secondly, farmers may not seek a loan because the risk implied by the available credit contract is too high. Perhaps this cost arises because lenders want to counteract the risk of imperfect information by asking for collateral. Collateral-based credit contracts may lead to quantity constraints but they may also lead risk-averse farmers to voluntarily exclude themselves from credit markets. This type of credit constraint is called risk rationing.

A common framework used to model the effects of credit constraints on farm output, and consequently, productivity, is a micro-economic agricultural household model where the utility maximization problem of a farmer depicts both the consumption and production decision of the farm household (Singh et al., 1986). In complete and competitive markets the consumption and production decisions of the farmers are separable, whereas in absent and non-competitive markets these decisions are not, meaning the product choice and factor productivities of the agricultural household are influenced by its preferences, characteristics, wealth, credit, and any other endowments. According to Benjamin (1992), this property of the independent household model can be used in empirical tests of market imperfections.

The recent empirical literature has tested for non-separability decision as being rooted in market imperfection, suggesting that non-separability should be applicable only to those farmers whose choices are constrained by the underlying market imperfections. If, for example, land, labor, or credit markets are completely absent and all farmers are constrained by their absence, then a common estimation test for all farmers is appropriate. But if only some of the farmers are constrained, then the non-separability should characterize only those constrained farmers.

In the case of a credit market imperfection, the non-separability decision needs to be tested for those farmers whose choices are constrained by it. As was explained before in this section, although pure credit rationing is the most frequently used definition of credit market imperfection, transaction cost and risk are two additional means by which asymmetric information may affect farmers' terms of access to the credit market and hence their resource allocation decisions (Guirkinger and Boucher, 2008). In all three categories of credit constraints, farmers have a demand for credit but they are limited 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.

Under this framework, Petrick (2004) develops a two-period household model that allows an analysis of the effects of credit rationing with respect to short-term loans. In Petrick’s model, a binding and pure concept of credit constraint results in a household-internal shadow interest rate that is above the market interest rate of a first best solution. Therefore, input use is reduced, which implies a drop in output, income, and productivity as compared with the first best. A further implication of the binding credit constraint is that it breaks the separability of consumption and production decisions.

3 Data and context

3.1 The study Area

The study area contains regions V, VI and Metropolitana, the central part of Chile. The counties selected from this area is based on the country's most important fresh fruit and vegetable production, and are Los Andes, San Felipe (V Region), Rancagua (VI Region), San Bernardo, Buin, Paine, and Melipilla (Region Metropolitana). Agriculture in this area is mainly irrigated and the well-developed system of reservoirs and irrigation and drainage canals greatly reduce risk associated with amount and timing of water. The predominant agricultural activity is fruit production, been the major crops table grapes, kiwi fruit and nectarines, apples, apricots, pears, and avocados. Much of Chile's fruit production of this area is exported during the northern winter to the USA, Canada and Europe. Chile also produces and exports large quantities of wine, forest products, planting seeds, fresh flowers and processed fruits and vegetable.

In contrast to the rest of Latin-American countries, large estates (*fundos*) occupy a substantial part of Chile's agricultural lands. These are remnants of the Spanish colonial period, when extensive land grants were made to army officers and colonial officials. In early 1920s, nearly 90 per cent of the farmland in central Chile was in large estates. Although a massive land reform was introduced in 1967 and strengthened in 1971, during a liberalization period during the 80's and 90's individual land tittles were distributed to the beneficiaries of the agrarian reform program. With the land titles distribution started a dynamic land market which has facilitated the merge of land into large productive firms. Based on the 2007 agricultural census, the average land size for agriculture activity in Chile is 60 hectares against 24 hectares for the study area. If we consider farmers with a minimum of 10 hectares, which is linked with market oriented famers, the average size for market-oriented individual farms in Chile is 64 and for the study area 68 hectares (Table 1).

Table 1: Average farm size for different regions in Chile, 2007

Regions of Chile	**Range of hectares**		
	0-9.9	**10-1,000**	**Total**
XV de Arica y Parinacota	2.39	150.81	25.97
I de Tarapacá	1.51	83.92	12.07
II de Antofagasta	1.67	39.50	3.02
III de Atacama	2.25	85.40	16.51
IV de Coquimbo	2.63	74.74	18.15
V de Valparaíso	2.67	80.42	21.85
Región Metropolitana de Santiago	3.32	68.39	27.87
VI de O'Higgins	2.72	62.73	23.98
VII del Maule	2.80	55.68	23.28
VIII del Bío-Bío	3.15	50.25	19.63
IX de La Araucanía	4.38	53.79	27.23
XIV de Los Ríos	4.23	65.50	36.02
X de Los Lagos	4.50	63.27	37.65
XI Aysen	3.97	241.09	203.03
XII de Magallanes y Antártica	2.56	225.82	89.68
Total country	**3.32**	**63.83**	**60.16**
Central Chile	**2.83**	**68.40**	**24.21**

Source: Author's computation based on the data provided by Instituto Nacional de Estadisticas (2007)

Over the last 30 years Chile's banking system has changed significantly In 1974–83, the Chilean government almost completely liberalized the financial sector by abolishing virtually all financial controls. However, the complete liberalization destabilized the economy, forcing the government in 1983 to step in and rescue the failing banks (Fry, 1994). The government also introduced a supervisory system for the financial sector (*Superintendencia de Bancos e Instituciones Financieras*), which is currently still in place. This regulation framework intends 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[1]: 12 foreign-owned, 7 Chilean-

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

owned and one state-owned bank (SBIF, 2009). In the last 20 years the financial sector has shown an outstanding growth rate. In 2001 the ratio of credit allocated by deposit money banks to GDP was 63.6% far higher than Brazil's, the second country in the region in this respect (Gallego and Loayza, 2004; Hernandez and Parro, 2004).

Table 2: 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 2 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 characterized by been heavily collateralized and available mainly to medium and large farmers. While bank's officers in Chile do sometimes visit farm borrowers these visit usually tend to take place prior to loan approval and with the aim to appraise the value of collateral assets and not to monitor the project during execution (Conning 2005). All the commercial banks have offices throughout the country, but concentrated in the central area.

3.2 Survey and data collection

At this point we introduce a methodological variation to the work of Petrick (2004). To measure credit constraint on farmers, we include non-price demand-side restrictions as in Boucher et al. (2009). Thus, in addition to the typical demographic and production sections, we added to our survey core questions dealing with credit behavior including information on loan sources, loan applications, credit contracts, credit from suppliers, traders, and collateral[2].

The survey was carried out in 2006 and 2008 and contains data on the 2005–2006 and 2007–2008 seasons, respectively. 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 200 farmers, 177 of which were in the first wave. The survey instrument was repeated with slight differences[3]. Table 3 provides descriptive characteristics of the farms taken in the sample.

[2]The Appendix provides the questions applied in the survey.
[3]The survey can be obtained on request.

Table 3: Sample statistics of surveyed farms (n=354, pooled sample)

Variable	Definition	Mean	Standard deviation
INCOME	Total farm output production (millions of Ch$)	358.32	424.37
HECTARES	Owned land (hectares)	76.80	111.22
SHORT- TERM CREDIT	Total outstanding short term credit from formal and informal lenders (millions of Ch$)	45.63	107.05
ASSETS NO HA	Total assets (machinery and facilities) net from hectares (millions of Ch$)	243.58	554.28
CLUSTER	Number of firms connected with the firm as a cluster	1.42	0.81
INSURANCE	1 if the firm use insurance instruments, 0 otherwise	0.03	0.18
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
LOCATION 1 SB	1 if the farm is located in San Bernardo, 0 otherwise	0.25	0.43
LOCATION 2 LA	1 if the farm is located in Los Andes, 0 otherwise	0.18	0.39
LOCATION 3 CA	1 if the farm is located in Cachapoal, 0 otherwise	0.37	0.48
ALMOND	1 if the farm has Almond as a main production, 0 otherwise	0.05	0.21
CHERRY	1 if the farm has Cherry as a main production, 0 otherwise	0.06	0.23
TABLE GRAPE	1 if the farm has Table Grape as a main production, 0 otherwise	0.29	0.46
WINE GRAPE	1 if the farm has Wine Grape as a main production, 0 otherwise	0.06	0.24
SCANNE PEACH	1 if the farm has Scanned Peaches as a main production, 0 otherwise	0.06	0.23

Note: 1,000 Chilean$= 1.58 US$; n stands for sample size

Table 4 reports the number and average amount of short-term loans differentiated by formal sector rationing categories. Formal short-term credit is most used by unconstrained borrowers, while informal short-term credit is most used by risk and transaction-cost rationed farmers. In total, unconstrained borrowers together with risk and transaction-cost rationed farmers use more credit than those in the rest of the categories. It is important to note that risk and transaction cost categories use only informal credit. This situation arises because farmers in risk and transaction cost categories consider formal credit either to be more risky or to bear too much transaction cost. This suggests that these types of farmers prefer informal over formal credit, redirecting their demand for short-term credit from a formal to an informal sources of credit.

Table 4: Number and average of short-term loans from formal and informal institutions by formal sector rationing categories, pooled sample

Formal sector rationing categories	Formal		Informal		Total short-term loans		Total sample
Unconstrained	***N***	$\overline{X}$	***N***	$\overline{X}$	***N***	$\overline{X}$	***N***
Borrowers	41	83.901	62	24.581	86	57.139	118
Non-borrowers	0		80	22.243	80	22.243	184
Constrained							
Quantity rationed	20	41.935	17	17.111	27	41.818	36
Transaction cost rationed	0		5	60.680	5	60.680	6
Risk rationed	0		4	65.689	4	65.689	10
Subtotal	**20**	**41.935**	**26**	**32.963**	**36**	**47.090**	**52**
Credit Constrained Categories							
Total	**61**	**70.142**	**168**	**24.765**	**202**	**41.528**	**354**

Table 5 shows the characteristics of farmers classified by rationing categories from the formal credit sector. Unconstrained borrowers and transaction-cost rationed farmers own more hectares than those in the rest of the rationing categories, while quantity-rationed farmers have less titled land. Farm size appears a variable that affects a quantity constraint, the most important category of credit constraints: The 36 quantity-rationed farmers averaged just 40.6 owned hectares each, whereas the total average is 76.8 hectares per farmer.

Table 5: Farm characteristics by formal sector rationing categories, pooled sample

Formal sector rationing categories	*Average Owned hectares* (*Ha*)	**Average assets** (**MM$**)	*Average gross Income* (*MM$*)	*Assets/ ha* (*MM$ /ha*)	*Income/ ha* (*MM$/ ha*)
Unconstrained					
Borrowers (n=118)	82.181	206.868	418.940	2.517	5.098
Non-borrowers (n=184)	81.835	273.291	347.125	3.340	4.242
Constrained					
Quantity rationed (n=36)	40.636	273.893	253.156	6.786	6.272
Transaction cost rationed (n=6)	83.283	31.306	376.067	0.376	4.516
Risk rationed (n=10)	46.800	148.477	216.992	3.390	4.954
Subtotal	46.742	221.783	260.383	4.745	5.571
Credit Constrained Categories (n=52)					
Total (n=354)	76.795	243.584	358.321	3.172	4.666

Note: n stands for sample size for each particular category and MM$ stands for Chilean peso in millions

The average value of assets per hectare is high for quantity-rationed farmers, which can be explained by their capacity to both invest and to acquire new equipment or by a negative relation between quantity rationing and farm size. On the other hand, the low value of assets per hectare for transaction-cost constrained farmers reveals either a low propensity to invest or a positive relation between transaction cost and farm size. Although investments are not the scope of this paper, this latter idea has to be tested taking into consideration endogeneity problems which arise for the variable credit constraint.

Unconstrained borrowers have the highest income. Although this may be related to access to credit, it may also be due to farm size. Unconstrained borrowers and non-borrowers as well as transaction-cost rationed farmers can be seen to have high levels of both farm size and income. Later we test to what extent farm size affects farm productivity.

4 Empirical model

4.1 Econometric specification: A model for the selection mechanism with panel data

In general a statistical model yields valid inferences only if the units, in this case farmers, are sampled at random. Selection bias may arise when the selection mechanism depends on unobservable variables correlated with the error term of the statistical model of interest. In our case, a farmer who operates at low productivity may have higher demand for credit as compared to more productive farmers. This may create selection bias in our estimators. A classic way to avoid the selection bias is to add an equation which explicitly models the selection mechanism (Heckman, 1979).

The sample selection model for farm productivity using panel data can be written as a system of equations for the substantive equation (productivity) and the selection equation (credit constraint). By treating the responses as repeated measurements nested within individuals, the sample selection model fits neatly into the multilevel framework (Skrondal and Rabe-Hesketh, 2004). Although there exist several other parametric (Wooldridge, 1995) and semi-parametric (Kyriazidou, 1997) techniques to deal with residual selection using panel data, we prefer to use multilevel analysis because it allows to use the entire set of data without using a subsample of farmers for which the constraint regime does not change across periods, as others techniques do. Let us label with y_{it} the output production for farmer i *(i=1,…, N)* at time *t (t=1,…,T)*. The binary variable CC^*_{2it} simply indicates the presence or absence of all three categories of credit constraints (quantity, transaction cost, and risk rationing). As was explained in section 2, non-separability should be tested for those farmers whose choices are constrained by credit market imperfections, either because of collateral, transaction cost, or risk. Then farm productivity can be observed only if a credit constraint ($CC^*_{2it} = 1$) is met. The joint model is thus defined by the following equations:

$$y_{1it} = x'_{it}\beta + \varepsilon_{1it} \quad \textbf{(1)}$$
$$CC^{*}_{2it} = z'_{it}\gamma + \varepsilon_{2it} \quad \textbf{(2)}$$

Where x_{it} and z_{it} represent the vectors of explanatory variables affecting output production 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 induce the dependence between both residuals, the residual in equations (1) and (2) are discomposed as $\varepsilon_{1it} = \xi_{1i} + \lambda\delta_{it} + \mu_{1it}$ and $\varepsilon_{2it} = \xi_{2i} + \delta_{it} + \mu_{2it}$. The three terms capture the unobservable heterogeneity: ξ_{1i} and ξ_{2i} are the random intercepts for each individual, normally distributed with zero mean and variance, $\sigma^2_{\xi_{1i}}$ and $\sigma^2_{\xi_{2i}}$, respectively and covariance $\sigma^2_{\xi_{1i};\xi_{2i}}$; δ_{it} is a shared random effect to induce dependence between substantive and selection equation by the factor λ, normally distributed with zero mean and variance σ^2_{δ}; μ_{1it} and μ_{2it} represent 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, $Var(\varepsilon_{1it}) = \sigma^2_{\xi_{1i}} + \lambda^2\sigma^2_{\delta_{it}} + \sigma^2_{\mu_{1it}}$, $Var(\varepsilon_{2it}) = \sigma^2_{\xi_{2i}} + \sigma^2_{\delta_{it}} + \sigma^2_{\mu_{2it}}$ and $Cov(\varepsilon_{1it}, \varepsilon_{2it}) = \lambda\sigma^2_{\delta} + \sigma^2_{\xi_{1i};\xi_{2i}}$. Equations (1) and (2) can now be rewritten as:

$$y_{1it} = x'_{it}\beta + \xi_{1i} + \lambda\delta_{it} + \mu_{1it} \quad \textbf{(3)}$$

$$CC^{*}_{2it} = z'_{it}\gamma + \xi_{2i} + \delta_{it} + \mu_{2it} \quad \textbf{(4)}$$

In the system of equations (3) and (4) there are six variance-covariance parameters, $(\sigma^2_{\xi_{1i}}, \sigma^2_{\xi_{2i}}, \sigma^2_{\mu_{1it}}, \sigma^2_{\mu_{2it}}, \sigma^2_{\delta_{it}}, \lambda)$. However, there are only four quantities to estimate: the residual variance of y_{1it}, namely $\sigma^2_{\xi_{1i}} + \lambda^2\sigma^2_{\delta} + \sigma^2_{\mu_{1it}}$; the variance of ξ_{1i} and ξ_{2i}, identified through the intraclass correlation in the substantive and selection model respectively; and the correlation between the total residual of the two equations namely:

$$\rho(\varepsilon_{1it},\varepsilon_{2it}) = \frac{\lambda\sigma_{\delta}^{2} + \sigma_{\xi_{1i};\xi_{2i}}}{\sqrt{(\sigma_{\xi_{1i}}^{2} + \lambda^{2}\sigma_{\delta}^{2} + \sigma_{\mu_{1it}}^{2})(\sigma_{\xi_{2i}}^{2} + \sigma_{\delta}^{2} + \sigma_{\mu_{2it}}^{2})}} \qquad \textbf{(5)}$$

Therefore, it is necessary to impose two restrictions. One restriction comes directly from the binary nature of the selection equation, so $\sigma_{\mu_{2it}}^{2}$ is implicitly fixed to a value determined in the model estimated in the selection equation (we use the probit model for the selection model, hence $\sigma_{\mu_{2it}}^{2} = 1$). The second restriction needed for identification must be stated explicitly: here we fixed the factor variance to one ($\sigma_{\delta}^{2} = 1$). For discussions and alternatives restrictions see Skrondal and Rabe-Hesketh (2004).

Thus the covariance matrix of the residual is given by:

$$\sum = \begin{pmatrix} \sigma_{\xi_{1i}}^{2} + \lambda^{2} + \sigma_{\mu_{1it}}^{2} & \lambda + \sigma_{\xi_{1i};\xi_{2i}} \\ \lambda + \sigma_{\xi_{1i};\xi_{2i}} & \sigma_{\xi_{2i}}^{2} + 2 \end{pmatrix} \qquad \textbf{(6)}$$

And the correlation is

$$\rho = \frac{\lambda + \sigma_{\xi_{1i};\xi_{2i}}}{\sqrt{(\sigma_{\xi_{1i}}^{2} + \lambda^{2} + \sigma_{\mu_{1it}}^{2})(\sigma_{\xi_{2i}}^{2} + 2)}} \qquad \textbf{(7)}$$

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

The estimation of this model is by maximum likelihood, with the likelihood function evaluated by the adaptive quadrature numerical technique shown by Rabe-Hesketh *et al*. (2005). This technique has shown to be superior to standard quadrature methods, particularly where the number of cross-sectional observations is large and/or the intra-class correlation is high. Maximization of the likelihood function over the set of parameters is achieved by the Newton-Ramhson algorithm. The productivity function is estimated as a Tobit model, which includes random effects for households-level heterogeneity (Rabe-Hesketh 2004).

4.2 Variable specification

The dependent variable in equations (3) is farm productivity, measured as the value of farm output production per hectare in Chilean pesos (Ch$)[4]. Due to the multiproduct farm households in central Chile, the value of farm production is an aggregate of fruit and horticultural crop production in 2006 and in 2008. The production is valued using prices declared by the household at the time of the household survey. In the case of exported products, we consider the average dollar (US$) value for each year to estimate total value of farm production in pesos.

The following independent variables are typically included to explain farm productivity (Feder, Lau et al., 1990; Moschini and Hennessy, 2001; Boucher, Guirkinger et al., 2009): short-term credit availability ($\overline{K}$), initial liquidity endowment (E), and household (z^h) and production (z^y) characteristics.

For credit available ($\overline{K}$) we consider the amount of credit borrowed from all available sources (formal and informal institutions). Because short-term credit is linked with liquidity available for current inputs and directly affects productivity, some authors state that short-term rather than long-term credit is the most appropriate variable for affecting productivity[5]. However, all credit available may also affect farm productivity as a result of continuous improvement in productivity by means of investments (Feder, Lau et al., 1990; Foltz, 2004; Guirkinger and Boucher, 2008). In addition, credit constraint variables consider both long- and short-term credit restrictions. From our data set, we cannot separate short-term from long-term credit restrictions. Although farmers from the survey are more likely to report long-term credit constraints, those constraints are not directly assessed in the survey. Nevertheless, to

[4] The exchange rate between the Chilean peso and the US dollar is 651 peso per dollar.

[5] It is important to note that we consider short-term credit as liquidity because households consider the allocation of resources at the beginning of the production period between current consumption, investment, and the purchase of variable inputs for current production (including labor and fertilizer). Variable inputs, in combination with land and existing capital, will produce this period's output. Because investment will not mature by the time this period's output is produced, investment in not considered as a factor in one-period production functions. It is just considered as initial capital. Thus long-term credit would not be a relevant variable for one-period production.

consider both arguments about the duration of the period pertinent to the outstanding credit variable and the possible mismatching of a period affecting credit constraint and outstanding credit variables, we estimate the switching regression model of farm productivity specified in equations (3) and (4) using two alternative variables proxying for credit variables: short-term and total credit availability. We define short-term credit as loans with a maximum maturity of 12 months because these types of loans are required to finance inputs or current consumption.

The credit variable will be relevant to indicate whether consumption and production decision are separated or not. If this variable is positively significant, there is evidence for non-separability, and farm productivity would be effectively constrained by lack of access to credit. If the credit variable is not significant, it would be not important to explain farm productivity, and credit is not a binding constraint limiting production.

The independent variable representing household characteristics (z^h) is education. The expectation is that the high-educated managers could have a positive impact on the farm's productivity. The household resource endowment (*E)* is represented by farm size because land is the most important asset that farmers have. The *a priori* expectation is that these factors have a positive influence on farm productivity. Production characteristics (z^y) are captured by the type of farm activity. We expect that for higher value crops such as avocados and grapes, the value of farm productivity is also higher.

The number of adult males or females in the household is not included in our analysis. Farmers in Chile do business as would a regular company. They hire workers for jobs and family members are normally not part of the farm's workforce. Instead, this study includes the characteristics of the owner and his or her abilities to take control of the business.

Thus, for farm productivity empirical model (equation 3), explanatory and observable variables are as follows (Table 6):

Table 6: Explanatory and observable variables explaining farm productivity

Explanatory Variables	Observable variables
Credit access (K)	Volume of outstanding credit (Ch$)
Endowment (Z)	Farm size (hectares)
Household characteristics (z^h)	Education
	Problems with export company
Production characteristics (z^y)	Specialization (type of fruit or vegetable)

In the credit constraint empirical model (equation 4), explanatory and observable variables are taken from previous studies (Foltz, 2004; Petrick, 2004; Guirkinger and Boucher, 2008) that analyzed this stage in detail. In this paper the model and independent variables used to determine credit constraint are as follows (Table 7):

Table 7: Explanatory and observable variables explaining credit constraint

Explanatory Variable	Observable variable
Initial wealth	Titled land (hectares)
Production characteristics	Specialization (type of fruit or vegetable)
Farmer's management skills	Problems with export company (0-1)
	Insurance
	No training and certification programs
	Education

5 Results

The primary objective of this paper is to determine to what extent available credit affects farm productivity of credit constrained farmers. As explained in section 4.1, we estimate the switching regression model of farm productivity specified in equation (3) and (4) using two alternative variables proxying for credit variable: short-term and total credit availability.

As farm productivity is observable only for credit-constrained farmers and as there is a likely correlation between credit constraints and income, we need to control for a possible selection bias within the panel data structure using switching regression models (Miranda, 2006). Although we recognize that modeling unconstrained farmers may suffer from misspecification and endogeneity problems not captured by credit constraint variables, all two specifications for farm productivity are estimated separately for credit-constrained and unconstrained subsamples to compare the significance of the parameters in both subsamples. The coefficients of the constrained sample selection model are estimated on 52 observations because only credit-constrained farmers are included. The rest of the observations (125) are used to estimate the unconstrained sample selection model.

Table 8 presents estimates of the two switching regression models of farm productivity for formal credit constrained and unconstrained farmers. All regressors from the productivity equation are regressors in the selection equation. However the selection equation has some variables excluded from the productivity equation to ensure identification of the model. The variables included in the selection equation and excluded from productivity equation are: whether use has made of insurance instruments, whether a training and a certification program has been completed, and a dummy for farm activities such as avocado and peach growing.

Before turning to the main results, we briefly comment on the parameter estimates of the selection equation representing the credit constraint (Equation 4). These parameters are reported in the first column of each model of Table 8. As expected, possession of land reduces the probability of being credit constrained in the two models. Titled land may be used as collateral which helps formal financial institutions overcome adverse selection and moral hazard problems. Another parameter that is significant and increases the probability of being credit constrained is the use of insurance. This result is in line with the Leland-Pyle model (Leland and Pyle, 1977). According to their model, poor organizations, or farms in this case, try to get full insurance, whereas good farms try to signal their quality by being only partially insured. This implies that farms that are insured are poorer-quality farms that will have a higher probability of being quantity rationed.

Finally, avocado and almond growers are more likely to be credit constrained. Two different reasons may explain this result: In the case of avocado growers, with a long tradition in Chilean agriculture, this result may reflect a situation where growers may reach a credit ceiling, and banks are less willing to extend extra credit. In the case of almonds, which is not a typical crop in Chile, the constraint may suggest that less experienced bank officers are assessing almond projects, so that banks may be less willing to extend a loan to these lesser known entrepreneurial activities.

Table 8: Parameter estimates of Switching Selection Model for farm productivity under binding and no-binding credit constraint

Productivity	Model 1 CC	Prod Cons	Prod Uncons	Model 2: CC	Prod Cons	Prod Uncons
HECTARES	-0.008***	-0.00695	-0.00345	-0.007***	-0.00179	-0.00326
	[0.005]	[0.595]	[0.364]	[0.006]	[0.918]	[0.392]
ST CREDIT	0.002	0.00176	-0.00282			
	[0.222]	[0.769]	[0.484]			
TOTAL DEBT				0.001	-0.00272	0.00330
				[0.453]	[0.762]	[0.215]
EDUCATION	-0.040	3.159**	-2.264**	-0.040	3.204**	-2.449***
	[0.899]	[0.035]	[0.012]	[0.901]	[0.034]	[0.007]
TABLE GRAPES	0.220	6.930***	2.453***	0.255	6.980***	2.340***
	[0.534]	[0.000]	[0.003]	[0.463]	[0.000]	[0.005]
ALMOND	1.184**	9.036***	-0.862	1.186**	9.119***	-0.730
	[0.041]	[0.000]	[0.670]	[0.039]	[0.000]	[0.718]
WINE GRAPES	0.777	8.555***	0.710	0.752	8.672***	0.607
	[0.157]	[0.001]	[0.665]	[0.168]	[0.001]	[0.712]
CHERRY	-0.183	4.738	5.014***	-0.180	4.762	5.112***
	[0.802]	[0.265]	[0.002]	[0.803]	[0.263]	[0.001]
EXPORT_PROB	0.511	-1.981	-2.123**	0.506	-1.946	-2.196**
	[0.117]	[0.125]	[0.013]	[0.117]	[0.133]	[0.010]
INSURANCE	2.915***			2.898***		
	[0.001]			[0.001]		
NO PROGRAM	0.413			0.413		
	[0.180]			[0.181]		
AVOCADO	1.520***			1.501***		
	[0.002]			[0.002]		
SCANNED PEACH	0.555			0.594		
	[0.316]			[0.277]		
CONSTANT	-1.603***	3.802**	8.332***	-1.617***	3.694*	8.251***
	[0.000]	[0.049]	[0.000]	[0.000]	[0.055]	[0.000]

Random Effect				
Observation level				
$\text{Var}(\mu_{1it})$	5.215**	11.489***	5.208**	11.387***
	[0.015]	[0.000]	[0.015]	[0.000]
$\text{Var}(\mu_{2it})$	Fixed	fixed	fixed	fixed
Individual level				
$\sigma^2_{\xi_{1i}}$	12.401**	15.403***	12.449**	15.488***
	[0.011]	[0.000]	[0.011]	[0.000]
$\sigma^2_{\xi_{2i}}$	5.295	11.970	5.444	12.133*
	[0.169]	[0.101]	[0.167]	[0.100]
$\sigma_{\xi_{1i}\xi_{2i}}$	-4.057	1.040	-4.048	1.2016
	[0.264]	[0.770]	[0.270]	[0.736]
CORR($\xi_{1i};\xi_{2i}$)	-0.501	-0.077	-0.492	-0.088
	[0.185]	[0.769]	[0.189]	[0.775]
Observations	406	656	406	656
Individuals	52	125	52	125
Log likelihood	-257.8	-1013.9	-258.3	-1013.8
LR Test	7.08***	0.18	6.38***	0.13
Wald-test (21)	88.63***	70.18***	89.44***	71.98***

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; $\sigma^2_{\xi_{1i}}$ and $\sigma^2_{\xi_{2i}}$ refer to the unexplained variance at the individual level for the farm productivity model and the selection model respectively; Likelihood ratio test (LR test) compares the exogenous (H0) with the endogenous model (Ha) and Wald test for the significance of all regressors but the constant.**

We now turn to the primary results of the regressions in Table 8. The second and third columns give parameters estimates for constrained and unconstrained productivity equations for short-term credit specification while the fifth and sixth columns do for constrained and unconstrained productivity equations for total debt specification .

The regression results of the farm productivity equation under a binding credit constraint for the two specifications show that the following variables affect farm productivity: education of the manager of the farm, and being almond, wine grape and table grape growers. The most important result, however, is the insignificant effect of short-term and total credit on farm productivity for constrained farmers. This result also indicates that constrained farmers, most of them quantity rationed, can separate production and consumption decisions and thus optimally choose their levels of input so that farm productivity is not affected. Although farmers feel themselves credit constrained, credit is not actually limiting their farm productivity. In other words, although farmers perceive themselves to be credit constrained, production and input-use decisions are not linked to their outstanding credit.

As expected, productivity for unconstrained farmers is not influenced by the availability of short neither by total debt. Although some farmers are credit constrained from formal credit institutions, the outstanding credit does not limit their productivity because they either have short-term credit available from informal institutions and probably shift demand for credit to the informal sector, or they find other sources to fund working capital such as cash reserves or near liquid assets. Indeed, we find little difference in the impact of short-term credit allocation on productivity for farmers that are constrained versus those who are unconstrained in the formal sector, suggesting that in the short term the informal sector is a good substitute or complement for an imperfect formal one.

Analyzing our control variables, we see that education is one of the variables that has a positive significant influence on farm productivity. This is an indication that education increases farm productivity. Given their constrained access to credit, more educated managers have more skills and tools to improve productivity.

Finally, variables related to specific farm activities also positively affect farm productivity under a credit constraint. For instance, almond growers, compared to farmers of other crops apart from cherries and table and wine grapes, increase their productivity by Ch$ 9 million per hectare (see model 1). In the meantime wine and table grape growers, compared to farmers of other crops, increase their income by Ch$ 8.67 and Ch$ 6.9 million per hectare, respectively. Good prices for these products in recent seasons may have affected these results.

The switching regression model for farm productivity under a binding credit constraint for the two specifications reports that the parameter is statistically insignificant. However, the LR test for selection bias is significant, suggesting that the selection bias is relevant under binding credit, and the coefficients may differ from constrained and unconstrained samples.

Since both ρ parameters for constrained and unconstrained farmers are statistically insignificant, this result is not conclusive with respect to whether or not credit-constrained or unconstrained farmers are more or less productive than a random farmer.

6 Discussion and conclusions

The present work analyses farm productivity conditional on selection criteria for access to formal credit using a panel data structure for market-oriented farmers in Chile. The complexity arises from the panel structure of the data and from the need to adjust for a possible selection bias. In our results, neglecting sample selection problems lead to biased estimators, for example for the impact of credit on farm productivity.

Most comparable studies suggest that while the productivity of unconstrained farmers is independent of their endowments such as liquidity, the productivity of constrained farmers is linked with their endowments. Specifically Guikenger (2008) suggests that credit constraints have a negative impact on productivity on constrained farmers in Peru. Their study suggests that Peruvian farmers do not have other financing alternatives such as an informal sector, capable to fully meet the liquidity need for constrained farmers in the formal sector. Their results break the independence between farmer`s resource allocation and endowments, implying credit market failures.

However, the most important result of this paper is that, despite some evidence of credit constraints due to asymmetric information and adverse selection prevalent in rural areas in Chile, the marginal effect of credit on farm productivity is nil across credit constrained and unconstrained farmers. Thus, access to credit does not seem to change farmers' production decisions for market-oriented farmers. The credit constraint condition is not binding, which implies that the available amount of credit does not restrict productivity and farmers do not need more credit to improve their income per hectare. A possible explanation for not finding significant effects for credit constrained firms in the formal sector is that informal credit institutions act as complement providers of credit. An active informal sector may thus relax credit constraints that prevail due to asymmetric information as well as risk and transaction cost.

This finding is relevant in a country like Chile that is currently discussing the pertinence of an agricultural bank, specialized in agricultural credit. Our results suggest that an increase in the availability of short-term credit will not have an impact on farm productivity. Others factors may have a larger impact on farm productivity such as education and farm activities such as avocado and almond.

However, more research is needed to understand the effect of credit constraints on long-term decision such as investment. This study highlights the high average value of assets for quantity-rationed farmers, which can be explained by their capacity to both invest and to acquire new equipment or by a negative relation between quantity rationing and farm size. More insight is therefore needed into the factors that lead the investment decisions process.

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Appendix

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 A.1 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 A.1 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 (Non-borrowers)
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	Constrained (Risk Rationed)
I did not want to be worried/ I was afraid.	Question 3, 4	
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	