# Effects of formal credit market and decisions to participate in off-farm activities on agricultural production of Small Farmers in Chile

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**D7**

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# Summary

*Understanding how complex the small farmers' situation is today is a great challenge, because not only do they face multiple problems, but also there is not a clear public policy concerning how those problems can be solved in the near future, a common characteristic in most developing countries. On the other hand, there is no doubt that more precise diagnosis of the small farmers' situation would significantly contribute to improve the public intervention in both the design of new instruments and the adjustment of existing ones.*

*This research focuses on the small farmer's production capacity, recognizing that there are other factors as important as production such as culture, values, poverty, and social networks. We analyzed the multiple factors that can affect small farmers' production. In particular, we studied the effects of the formal credit market, the off-farm labor market and production diversification on the agricultural production. To do that, we used a country-wide sample of small farmers collected in 2004 by INDAP, a public institution that provides credit and extension services to small farmers, and we studied different groups of producers, specialized and non-specialized, by conducting econometric analyses. The techniques of Stochastic Frontier Analysis and Switching Regressions Models were the methodological frameworks used to analyze a sample of 835 farmers, and the analyses were carried out based on household models. Additionally, the econometric results took into account the heterogeneity among farmers, and the endogeneity associated with selectivity processes.*

*The main results of this research show that there are different production structures among the production sectors analyzed. The formal credit market plays a role in explaining differences in production levels among farmers both in relative (efficiency analysis) and absolute (regime change analysis) terms.*

*In addition, based on a theoretical framework, we could not find evidence to support the hypothesis of Liquidity in the farmer groups analyzed. On the other hand, in the case of non-specialized farmers, we found that both on-farm production diversification and participation in off-farm activities decrease efficiency among small farmers. Moreover, the results would suggest that, in general, the intervention of public policy has not produced the expected outcomes in terms of production, and the practices of extension, independently of who finances them (publicly or privately), have not been successful in producing changes in production levels. Factors related to localization, irrigation, demographical characteristics and direct decisions of farmers with regard to management on-farm, participation in off-farm activities, specialization on farm, and dependence of on-farm income on total income are key elements to understanding what is going on at the efficiency level.*

*From those results, it has been shown that analytical tools are available to advance towards better diagnosis in small farmers. The challenge is to encourage public and private institutions to use them in order to improve their policies. Finally, it would seem pertinent to investigate in more detail the impact of public policy and extension services on productivity, based on a more systematic and detailed database, a task that in the current institutional-political structure should be led by INDAP in the next few years.*

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## Abbreviations

| | |
|---|---|
| SFA | Stochastic Frontier Analysis |
| SRM | Switching Regression Model |
| INDAP | Agricultural Development Institute |
| OLS | Ordinary Least Squares |
| WLS | Weighted Least Squares |
| ML | Maximum Likelihood |
| FIML | Full Information Maximum Likelihood |
| TE | Technical Efficiency |
| HL | Hypothesis of Liquidity |
| IMR | Inverse Mills Ratio |
| LR | Likelihood Ratio Test |
| LM | Lagrange Multiplier Test |
| LLF | Log-Likelihood Function |
| SP | Shadow Price |

# Chapter I

# Introduction

Chile is a country with a privileged geographic location, great variety in climate, and riches in renewable natural resources; thus Chilean agriculture has become one of the main productive activities showing a very interesting growth dynamic during the last three decades. There have been various explanations for this, but there is no doubt that Chile's trade opening process and its sectorial public policy help to explain the current achievements. As result of the opening process, tariffs have systematically dropped in the last years; however, at the aggregate level, agricultural producers have maintained their production levels or even, in some cases, have increased them.

At the production level, it is possible to distinguish three kinds of agricultural producers in Chile--small, medium, and large-- each one having different challenges and realities. According to official information, there are more than 278,000 small farmers in Chile with an average of 14 hectares, accounting for 85% of the total farmers. They represent not only production activities, but also traditions, culture, and values, which give a national identity. On the other hand, this small agriculture is characterized by a high heterogeneity in production, technology, access to financial markets, participation in off-farm activities, and grades of production diversification.

Small farmers in Chile have been facing several changes in their living and production conditions. In fact, there is no doubt that the living conditions of rural inhabitants depend more strongly on off-farm earnings; however, heterogeneity and diverse production capacities among farmers can be explaining important differences in their productivities and efficiency levels. On the other hand, there exists the impression that the current conditions of the Chilean economy are more favorable for certain types of producers. Livestock production is seen as a sector with attractive growth opportunities because of its export orientation, and, in contrast, activities such as crop production are perceived with some threats and low profitability levels. In addition, many people believe that agricultural development strongly depends on access to credit, market that is characterized by important asymmetries of information.

In this context, public policy has many challenges. On the one side, to enhance the levels of productivity at the farm level, and, on the other side, to provide development instruments that foster non-farm activities in rural areas, and to improve the access conditions to the formal credit market for small farmers. Those challenges are very difficult, especially when rural development is not a national priority.

In general, public policy has been working on the design of new financial instruments, has had active participation in rural credit markets, basically helping small farmers to have access to credit under more favorable conditions, or directly subsidizing the interest rates of credit, and has been developing institutions ad-hoc in order to foster the development of private institutions that help with financial intermediation. Additionally, different public institutions have developed several initiatives in rural areas by providing infrastructure, services, incentives for new enterprises, and sectorial subsidies. The idea has been to build a favorable environment for developing sustainable activities, either agricultural or non-agricultural, that help the rural inhabitants to overcome their current problems. However, the rural development strategy followed by countries, by developing countries, in particular, has not been clear. On the one hand, the massage has been to follow producing with a high performance and efficiency on-farm, and on the other hand, to get involved in off-farm activities as much as possible. Additionally, at the farm level, farmers do not know whether they should be more diversified or more specialized, in particular in economies with a high trade exchange with the rest of the world. Similar dilemmas face the Chilean public policy.

Thus, the future of the smallholders is not only based on access and consolidation of markets, but also on technological advances, improvements in management capacity, access to financial markets, and capacity to get involved in off-farm activities. Therefore, *public policy should take into account those elements to design new instruments and to adjust the current ones*. Thus, in order to improve public policy, we have to understand the nature and patterns of household income diversification, and have more precise diagnostics concerning the production structure and efficiency levels of small farmers. Therefore, several questions related to the functioning of the credit and labor markets should be considered, in particular when it is believed that decision-making processes of the farmers take place in a context characterized by imperfect markets.

If we exclusively focus on agricultural production of small farmers, we can identify at least two issues that are very important for the present and future discussion. First, we should understand what happens with their levels of efficiency, and what forces are behind them, focusing on the impact of formal credit market conditions and the decision to participate in off-farm activities on efficiency levels. Second, we should have an idea about the effects of the credit market conditions on production of small farmers. From those issues we can formulate the following research questions:

- ✓ What are the technological parameters of small farmers?
- ✓ Are these inefficiencies basically explained by access to the credit market?
- ✓ Has public policy contributed to increasing the efficiency levels of small farmers?
- ✓ Does specialization help to get higher efficiency levels?
- ✓ Does participation in off-farm activities affect technical efficiency of small farmers?
- ✓ Is there evidence that credit is only important for constrained farmers in their production decisions?
- ✓ Based on the literature of Treatment Effects, do credit and credit constraints have a considerable impact on the average production levels in small farmers?

Thus, using a country-wide sample of small farmers collected in 2004 by INDAP, a public institution that provides credit and extension services to small farmers, we studied different groups of producers, specialized and non-specialized, and conducted econometric analyses on them. The data collected is based on a representative sample with a sampling error of 5%, accounting for the different productive realities along the country.

The main objective of the research is *to understand the factors that are behind production at the small farmer level, and in particular, to analyze the role of the credit market and off-farm labor market on production, taking into account the heterogeneity among farmers.* Further, the specific objectives of the research, which arise from the research questions, are:

- ✓ To determine technological parameters of small farmers
- ✓ To determine whether inefficiencies are explained by the credit market conditions
- ✓ To determine whether the grade of specialization affects the inefficiencies
- ✓ To determine whether public policy affects the inefficiencies
- ✓ To determine whether the participation in off-farm activities increases inefficiencies

- ✓ To determine whether credit is important in the production decisions of constrained households
- ✓ To determine the impact on the average production associated with receiving credit and facing credit constraints

To do that, the research is basically focused on three studies. The first study measures the relative technical efficiency in specialized small farmers, and attempts to identify the main factors behind inefficiency observed. In particular, this work investigates the importance of credit and credit constraints on efficiency by taking into account the potential simultaneity of those variables with technical efficiency. The second study measures and explains relative technical efficiency in non-specialized farmers, focusing on how household's decisions to participate in off-farm activities affect technical efficiency, and how those decisions are affected by processes of self-selection and endogeneity. Moreover, a technology with different production orientations is modeled, and the grade of diversification is explicitly considered as a variable that determinates the efficiency level. The third study, based on the literature of Treatment Effects, explores the impact of formal credit market on average production, analyzing the changes in the average production between a group treated and another one untreated. Additionally, based on a theoretical model, the hypothesis of liquidity (HL) is checked.

The data base is divided into two groups: specialized and non-specialized producers. The specialized producers are grouped into crop and livestock producers, and the non-specialized producers are composed of crop-oriented, livestock-oriented and diversified producers. The first study analyzes only the specialized producers, crop and livestock. We selected them because they have different perspectives of development in the Chilean economy and the public policy and private actions have had some bias during the recent years. The second study analyzes the non-specialized producers, because the objective in this study was to pay attention to farmers that have some grade of diversification in their agricultural production mix, and we are also interested in studying how this diversification affects the levels of efficiency. In this way, we could get some insights about how the agricultural production structure affects the scores of technical efficiency. The third study deals with the entire sample.

The main contributions of the research are:

- ✓ This research is the first one in Chile that deals with estimations of technical efficiency, technological parameters, and the impact of the formal credit market conditions on small farmers by using a country-wide sample.
- ✓ This research analyzes different production sectors in order to check for differences in the results found.
- ✓ This research analyzes the impact of some financial variables on technical inefficiency by explicitly considering problems related to their potential simultaneity with inefficiency and tries to assert a different point of view concerning the impact and outreach of credit constraint on small farmers.
- ✓ This research models inefficiency, taking into account its heteroscedastic behavior, which is new at the small-farmer level.
- ✓ This research models the production technology of farmers by taking into account differences in production elasticities among different sectors.
- ✓ This research analyzes the statistical relation between technical efficiency and participation in off-farm labor by considering the potential endogeneity of the decisions of participation.
- ✓ This research checks whether switching regression models are appropriate in this context by testing the assumption of normality.
- ✓ This research estimates, based on the literature of treatment effect, the impact of both credit constraints and credit on average production by using consistent estimates.

The outline of the research is as follows. Chapter II provides the background of the Chilean agricultural sector, showing how the reforms carried out in the seventies condition its current situation. Additionally, small farmers are characterized and public policy related to financing and extension services is discussed. Chapter III presents the study's conceptual framework, the stochastic frontier analysis and its recent advances in dealing with heteroscedasticity in the inefficiency term are summarized, and the switching regression models and their estimation methods are presented in order to know their main advantages and disadvantages. In addition, two household models are sketched; the first one shows the role of credit in a context with credit constraints, and the other one shows the household's decisions to participate in off-farm activities, which permits us to formulate empirical models based on microeconomic foundations. Additionally, this chapter reviews the empirical applications that have been conducted using this methodological frame. Chapter IV presents the database used and the variables are defined. The source of information is presented, showing how representative the sample used is. The variables directly collected are presented, and it is explained how the family labor force was estimated. Moreover, the study unit is clearly defined, and how the final database is obtained, distinguishing among different kinds of farmers. All of this is the staring point to carry out the studies, which are presented in Chapters V, VI and VII. The structure of each study is an introduction, a model specification and data analysis, the presentation of methodological framework, and the results of the estimations with a discussion of them. Finally, Chapter VIII presents the conclusions and suggests future research.

The abstracts of each study are the following

**Study 1:**

***Financial Markets and the Determinants of Technical Inefficiency among Specialized Small Farmers***

*This work studies two groups of specialized producers in Chile, crop and livestock, analyzing their technologies, levels of technical efficiency, and the relation between access to capital markets and technical efficiency. Using data collected in 2007, we estimated stochastic production functions for 109 livestock and 342 crop producers. The results show that given the available data, a technology translog and a heteroscedatic inefficiency fit better than a Cobb Douglas technology and a homoscedastic inefficiency model.*

*At the sample mean, the crop production shows return constant to scale and the livestock production presents increasing return to scale, suggesting for the latter that farmers are operating at a sub-optimal size. The mean technical efficiency is 89% and 78% in crop production and livestock production, respectively. The technical efficiency increases with decreasing use of inputs, a higher dependence of on-farm income, more educated farmers, bigger family size and older head of family. Public policy does not affect the efficiency in crop production, unlike the situation in livestock production. The extension services seem not to help farms in getting higher levels of efficiency; even in the case of crop production, those services act directly opposite to what is expected*

*Observing differences in impact in each sector, the variables related to access to formal credit markets are important in explaining technical inefficiency. Credit has a positive impact on efficiency in crop production and a negative impact in livestock production.*

*On the other hand, constrained farmers are less efficient in crop production and more efficient in livestock production. Those results were checked by analyzing the potential simultaneity of the financial variables with the technical efficiency. We can not reject the hypothesis of no simultaneity in crop production, but we can in livestock production. We justify this finding from an institutional perspective; lenders have more information and knowledge of farmers in livestock production, because of a public policy oriented to sectors with a more direct exporting orientation. The estimations corrected in livestock production confirm our previous results; however, this procedure affected other parameters both in the production function and the inefficiency model. This finding is interesting and stresses the necessity of checking endogeneity in the variables used to model the inefficiency effects.*

## Study 2:

### *Technical Efficiency and Off-farm activities among Non-specialized Small Farmers*

*More diversification and participation in off-farm activities are commonly claimed at different levels as a solution to the difficult situation of most small farmers. Using a country-wide sample, this work uses a stochastic frontier analysis to analyze whether this statement has support for the case of Chilean non-specialized small farmers. The variance of the inefficiency is modeled taking into account the potential endogeneity of the participation in off-farm activities and credit.*

*A flexible production function is estimated identifying differences in the partial production elasticities among farmers with different production biases. The findings show that if the objective is efficiency, diversification and participation in off-farm activities do not contribute to strengthen it. Moreover, when endogenity is considered, the estimation of the underlying technology improved and more insights about the factors behind the efficiency emerged.*

*The technology studied is well-behaved with a production function homothetic and constant return to scale. The partial production elasticity of working capital fluctuates between 0.19 and 0.57, depending on the type of producer, the availability of irrigation, and whether endogenity is considered. The best model when endogeneity is taking into account showed a mean efficiency of 72%. The share of the on-farm income on the total income, the family size, the level of education of head family, the efforts for improving the management, and a production biased towards livestock activities increase the efficiency levels. On the other hand, the increasing use of the inputs working capital and* *labor, the age of head family, the extension services and the household participation in off-farm activities decrease the efficiency level.*

## Study 3:

***Credit and Production: A Micro-econometric Study of small farmers***

*This work explores whether the formal credit market affects the "average" production of small farmers in Chile. Using a country-wide sample, three groups of producers were studied; crop (437), livestock (213) and mixed (165) producers. A switching regression model was used, checking the normality assumption of error terms. The tests conducted showed that there is not evidence to support such an assumption in crop production, which means that we have to interpret with caution the results obtained in that sector.*

*Based on a theoretical framework, the hypothesis of liquidity (HL), which states that for the constrained farmers the production decisions depend on credit, was tested using Full Information Maximum Likelihood (FIML). The results showed that there is not evidence in favor of this hypothesis in the three groups analyzed.*

*On the other hand, taking into account selection bias and heterogeneity among farmers, the impact on the average agricultural production of credit constraint and credit was measured based on the literature of Treatment Effects. A switching regression model was estimated in two stages using the entire sample. This procedure permits us to consistently estimate the parameters and to separate the total effect estimated into observable and unobservable factors. The results suggest that total effect of credit increases the production value in mix production (14%) and decreases it in livestock production (36%), without effect on crop production. This suggests that in crop and livestock production the descriptive association between credit and production performance is a spurious result of the fact that those who produce with credit face a more favorable environment and/or are intrinsically better producers even without credit. On the other hand, the effect of credit constraints on the average production value is positive in crop production (86%), without effect in mix production, and negative in livestock (12%). The latter result means that if those livestock farmers had not been constrained, they would have increased their average production value by 12%.*

*Finally, our results point out the necessity of checking both normality and the differences between the parameters of the regimes in order to justify the use of switching regression models.*

# Chapter II

# Chile background

## 2.1 Reforms and adjustments

Chilean agriculture has become one of the main sectors of the country's economy. In this agricultural development, the incorporation of new and better technology, improvements in cultivation and animals and the innovative dynamism of farmers are the source of the outstanding growth that has been reached. Since Chile opened to external markets at the end of the seventies, the agricultural sector has had a dynamic characterized by a fast growth with radical changes in the use of the soil, as well as in the types of cultivation. At the same time, developments in international trade have occurred with a high diversification in markets and products, exporting more than 200 products to more than 100 countries, principally the United States, Japan and the European Union. At the same time, the composition of the exports has moved to include products with more added value, allowing the industrial sector to represent about 45% of the total exports in 1990, and more than 70% in 2004.

The Chilean agricultural sector has shown important trends in the last two decades, such as a switch from production based on traditional crops to agro-industrial production, increased diversification of productive structure and markets requiring higher added value, significant market expansion due to implementation of trade agreements, international consolidation of some products and productive specialization in activities where the country has comparative advantages and has incorporated more added value.

Between 1950 and 1973, the Chilean agricultural sector was characterized by controlled markets and land reform policy[1]. At the beginning of the 1970s, radical changes occurred,

[1] In 1967 a massive land reform was introduced by expropriations, with partial compensation determined by the Estate, and oriented toward the establishment of large, cooperative farms. Thus, a private producer with more than 80 hectares of irrigated land or its equivalent was subject to expropriation. A detailed review of the land reform policy and its effects on the Chilean agriculture is found in Jarvis (1985), Kay (2002), Jarvis *et al.* (2004) and Bellisario (2007).

principally policy changes oriented toward open trade, privatization and economic deregulation. The role of Government in the economy was reduced, trade was liberalized, and private property rights were strengthened. In 1975, the government eliminated price controls, except for wheat, milk and oilseeds. Legal ceilings on interest rates were raised and then removed and preferential rates for agriculture were abolished. As part of the early introduction of a radical trade liberalization program, almost all non-tariff barriers were eliminated and tariffs on most imports were rapidly reduced. In general, the policies of the Pinochet regime succeeded in maintaining a high real exchange rate and at the beginning of the 1990s, the democratic regime faced an episode of currency appreciation, creating political tension in the farm sector for both exporters and importers[2]. For producers that were competing with imports, the decline in profitability became even more pronounced when Chile joined MERCOSUR in 1996 as an associate member obligated to grant trade preferences to Argentina and Uruguay, countries with competitive exports in wheat, maize, oilseeds and beef.

The main impact of liberalization on agriculture was to alter the composition of production and trade. As suspected, the sub-sectors of exportables–fruits, vegetables and forestry–increased in importance, while livestock and field crops (primarily wheat) declined (**Table 1**).

**Table 1**
**Change in land use in Chile**
**(Thousands of hectares)**

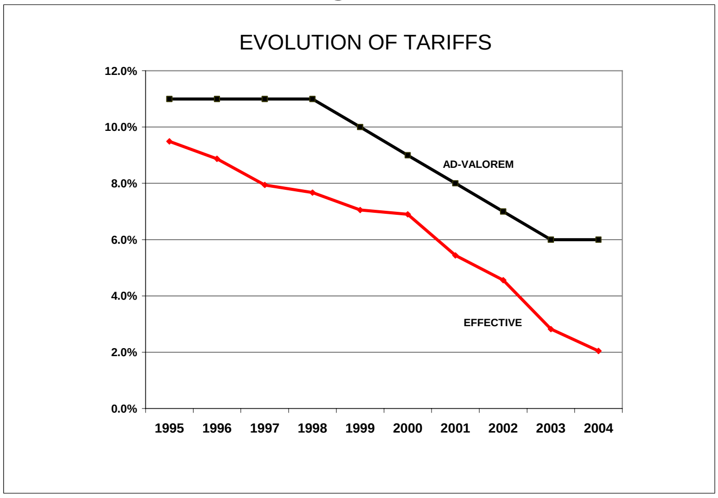
| GROUPS | 1976 | 1997 |
|---|---|---|
| Fruits | 89.5 | 234 |
| Vineyards | 106 | 81.3 |
| Forestry | 627.5 | 1097.3 |
| Greenhouse and flowers | 103.8 | 113.1 |
| Crops | 843.1 | 647 |

Source: Own calculations using information from Agricultural Census (1997).

One interesting fact is that despite the strong reduction in the levels of protection, the number of used hectares in crop production such as potatoes, maize and rice have maintained levels close to those observed at the beginning of the 1990s (**Figures 1 and 2**). At the same time, it is possible to observe strong fluctuations between 1996 and 1999, which might be explained by the Asian crisis and the incorporation into MERCOSUR.

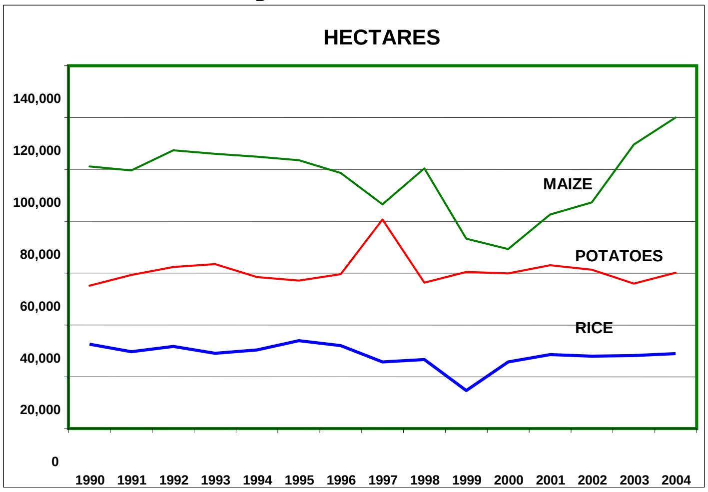
2 A review of Chilean economic reforms is found in Quiroz *et al.* (1988), Barahona and Quiroz (1990), Hurtado *et al.* (1991), Hachette and Rozas (1993), Venezian and Muchnik (1994) and Portilla (2000).

**Figure 1**




Source: Own calculations using information from Agricultural Census (1997)

**Figure 2**
**Evolution of used hectares in some important crops for small farmers**




Source: Own calculations using information from Agricultural Census (1997)

Between 1976 and 1997 the composition and size of farmers have shown a small difference among the country's regions. The central regions close to Santiago, with a strong profile in fruit and wine, show both a large decrease in farm numbers and a large increase in average farm size. This result differs from the regions located in the south, whose profile is basically crop and livestock, showing increases in the number of farms and decreases in farm size (Valdes and Foster, 2006).

In the last 10 years, the development bases of the agricultural policy have supported internalization, improvement of access to markets, promotion of innovation, technological development, improvement of enterprise management and access to financing sources. The driving force in the last few years in the agricultural sector has been a program with the goal of getting a better level of competitiveness. Specifically, these resources have been used in training and developing markets, irrigation systems, innovation and management, productive recuperation of soils, forestry production and sanitary improvement. Thus, of all the resources that were spent between 1997 and 2004, 32% has focused on innovation and management, 30% in development of irrigation systems and 26% in recuperation of poor soil (Chilean Ministry of Agriculture, 2005). The evaluation of the use of these resources is positive when the control variable is the number of people benefited, the surface covered, and the number of enterprises.

## 2.2 Small farmers in Chile

Based on the most recent agricultural census of 1997, there were more than 278,000 small farmers in Chile with an average of 14 hectares, accounting for 85% of the total farmers and more than 40% of crop, cattle and vegetable production (**Table 2**).

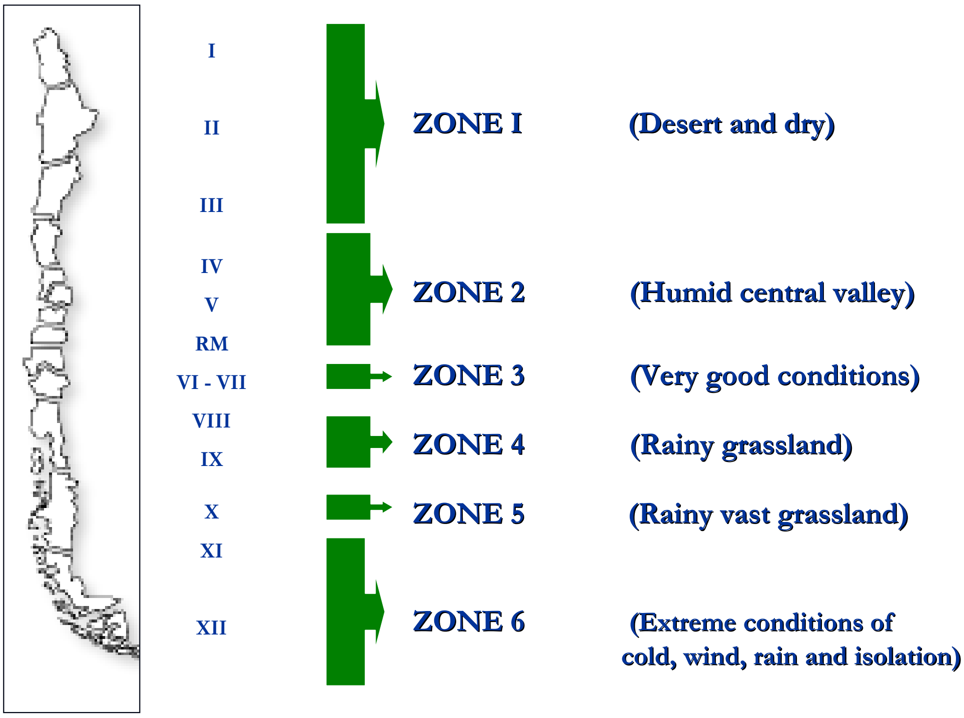
**Table 2**
**Importance of small farmers in Chile**

| Items | National | Small farmers | Share of the small farmers |
|---|---|---|---|
| Number of farmers | 329,705 | 278,840 | 85% |
| Crops (he) | 955,161 | 417,769 | 44% |
| Vegetables (he) | 127,305 | 57,038 | 45% |
| Vineyards (he) | 82,174 | 33,422 | 41% |
| Fruits (he) | 237,363 | 69,652 | 29% |
| Forestry (he) | 2,232,798 | 360,533 | 16% |
| Cattle (heads) | 4,140,247 | 1,754,696 | 42% |
| Dairy cow (heads) | 617,612 | 261,830 | 42% |

Source: Own calculations using information from Agricultural Census (1997)

It is important to have a clear view of small farmers and their production structure; the country is geographically divided into six macro zones, each macro zone containing more than one region in most cases. Thus, for example, macro zone 1 is a zone characterized by desert and dryness, and which accounts for 2% of small farmers (**Figure 3 and Table 3**). Small farmers that produce crops are basically located in macro zones 2, 3 and 4, accounting for 89% of the total, and cattle production is located in macro zones 3, 4 and 5, accounting for 86% of the total cows.

**Figure 3**
**Macro zones in Chile**




Source: Own calculations using information from Agricultural Census (1997)

**Table 3**
**Share of small farmers in different activities by macro zone**

| | N of farmers | Crops | Veget. | Vineyards | Fruits | Forestry | Cattle | Dairy |
|---|---|---|---|---|---|---|---|---|
| Total | 278,840 | 417,769 | 57,038 | 33,422 | 69,652 | 360,533 | 1,754,696 | 261,830 |
| | Share | | | | | | | |
| Zone 1 | 2% | 0% | 2% | 1% | 2% | 0% | 0% | 0% |
| Zone 2 | 15% | 4% | 28% | 13% | 26% | 8% | 6% | 5% |
| Zone 3 | 23% | 33% | 45% | 36% | 39% | 35% | 12% | 8% |
| Zone 4 | 39% | 52% | 16% | 49% | 17% | 50% | 36% | 24% |
| Zone 5 | 19% | 11% | 9% | 0% | 15% | 6% | 38% | 61% |
| Zone 6 | 1% | 0% | 1% | 0% | 0% | 1% | 8% | 2% |
| Zones 2 - 5 | 97% | 100% | 97% | 99% | 98% | 99% | 92% | 98% |

Source: Own calculations using Agricultural Census (1997) and Office of Studies and Agricultural Policy (ODEPA)

## 2.3 Extension services and financing

In Chile, extension services are provided by private agencies on the basis of state subsidies, and INDAP, a public institution that promotes agricultural development in small farmers, defines overall policy orientation, manages funds, assesses bids, defines the general methodology for the program, conducts monitoring and evaluation, and provides training to the staff of the companies that provide these kinds of services. Since its introduction in 1978, Chile's privatized technology transfer program has constantly evolved to deal with the problems and issues that have arisen as a consequence of the sub-contracting mechanisms used to implement the program. It has also evolved in its concepts and methods.

The government has conducted some evaluations of the extension service program. Results have indicated that the system has had a positive impact on key indicators of agricultural and technological performance. From this study, the Chilean extension program would has played a very positive role in supporting the development of more competitive, diversified and productive small-scale agriculture in Chile, but also has had a positive role in the alleviation of rural poverty. However, Lopez (1996) found opposite results, showing that the participation in the public extension program did not significantly increase the income of the small farmers, although he found a significant effect on farm production. One interesting finding of this study was that greater farm output was not caused by a higher productivity but was merely the effect of a greater use of inputs where the inputs costs increased considerably in efforts to intensify farm production. On the other hand, Bebbington and Sotomayor (1998) point out that the impact of the extension program could be explained by the limited market orientation and rigor of the types of technical assistance that have been given to small farmers in the past. In other words, a low quality of services delivered could be another cause. According to Berdegue and Marchant (2000), the evolution of the extension system has solved many of the operational problems such as excessive politicization, inefficiency of operations at the field level, and lack of operational budget.

The financing of the Chilean agricultural sector is mainly based on private sector resources such as farmer’s resources, capital market (formal and/or informal), funds from agro-industry and export companies. In this context, INDAP provides credit to a large number of small farmers who have difficulty getting financing with the formal credit market. According to Quiroz (2002), the amount of money lent to small farmers is clearly insufficient and the share of agricultural formal credit over total credit lent by the financial institutions has clearly decreased in the last ten years. The same study points out that the lack of specialized banks in the sectorial risk analysis is one of the most important problems. Furthermore, this study identifies some problems concerning financial regulation that have not permitted a higher share of the formal credit market. In effect, banks look at the agricultural sector, especially the small and medium farmers, with extreme prudence. Under this situation, some initiatives have emerged, for example, the development of specialized platforms for agricultural project evaluation and new financial tools such as forestry securitization, crop insurances and guarantee funds for small farmers; however, they have not had the impact expected.

In addition, INDAP provides direct subsidies which have generated some effects differentiated on the incentives and levels of production in certain activities. Not only public policy but also the private sector has followed a behavior with some kind of sectorial bias, making differences between the crop and livestock sectors regarding credit market, market signals and subsidies (or programs).

The instruments related to access to credit would apparently be more developed in crop production than livestock production, which could be explained by a longer history in the country's agricultural economy and a more direct relation between credit and production in the short run. Thus, INDAP and Banco Estado, the main institutions of financing, have responded by designing special products according to the necessities of this sector. On the other side, livestock production faces a less developed credit market, having fewer possibilities to get credit, not only in the short run but also in the long run. According to lenders, it is more difficult to evaluate a credit in livestock production than crop production because those farms have weak relations with agro-industry, a diffuse connection between credit for the short run and annual production and a bigger difficulty in structuring collaterals.

However, since joining MERCOSUR, the perception of those sectors has markedly changed. Crop production is seen as a sector without development opportunities, but with the capacity to survive, producing at competitive levels. On the other hand, livestock production experienced difficult moments at the end of the 1990s, but since then perception of the sector has been changing to become a sector with interesting opportunities based on the new trade agreements signed, where markets of high value seem to be very attractive. In this context, the signals given by public policy have motivated the association and cooperation of institutions, public and private, to take advantage of this new situation.

Under this new view, public policy has reacted by providing new programs and instruments to support livestock production. Some examples are the support given to improving grassland, the delivery of direct subsidies to improve genetic, production procedures, and quality and quantity of herd. Further, the government has enhanced the creation of some centers of information for livestock producers in Chile's south region in order to know who is who in terms of productivity, cost, reputation, and market perspectives. It is likely that those kinds of initiatives have created a new sort of relation between lenders and farms.

# Chapter III

# Conceptual Framework and Empirical Applications

The objective of this chapter is basically to review the state of arts at the conceptual and empirical level of the techniques that will be used to resolve the research questions proposed in Chapter I. Thus, going through the contents of this chapter, it will be possible to see more clearly the necessity for this research either because the existing evidence is not conclusive in some cases or because the research questions that are claimed in this research have not been analyzed in others.

This chapter presents the conceptual framework and some empirical applications that have been used with those techniques during recent years. First, we present household models to explain the role of credit constraint in the decision-making processes, which will be used in Chapter VII to analyze if the credit is important for constrained household (hypothesis of liquidity, HL). In addition, we briefly discuss the expected results in terms of technical efficiency when a household faces credit constraints. This will be the starting point to interpret our results when we estimate technical efficiency in Chapter V and try to explain the effect of this variable on efficiency estimated. Moreover, we develop the theoretical bases that are behind the household decisions to participate in off-farm activities, which will permit us to model equations of participation in Chapter VI when we use this variable to explain differences in efficiency estimated.

Second, we present the methodology to estimate and model relative technical efficiency focusing on recent advances for dealing with heteroscedastic processes at the inefficiency level. This will be the theoretical framework to develop Chapters V and VI. Empirical applications that have used this technique at the farmer level will be presented. Additionally, we show an extended review of papers that have studied the relationship between technical efficiency and credit, technical efficiency and credit constraint, and technical efficiency and decisions to participate in off-farm activities.

Third, the methodology of switching regression is presented in terms of its conceptual justification, the estimation techniques used to estimate it, and some applications that have been carried out in the agricultural sector in recent years. This technique will be used in Chapter VII where the impact on the average production will be measured based on the literature of *Treatment effects*. The impact is defined as the change in the average production value level caused by the treatment, which in this case, would be either to receive credit or to be constrained. This is a different line of research with regard to Chapters V and VI.

This approach is quite different from the methodology of efficiency analysis which is focused on the farmer and tries to measure how far a farmer is from his estimated frontier based on a comparative analysis among all farmers. Conversely, the literature concerning the Treatment Effects works on changes in the average production without going on to analyze the situation at the farmer level. Thus, the insights that can be gotten with this technique provide additional information to the studies of efficiency. Finally, we discuss some papers that have tried to connect the approaches of efficiency analysis with the switching regression models.

## 3.1 Household Models

### 3.1.1 Credit in a Household Model

Credit can be understood as a variable or fixed input depending on the problem that we want to study. Moreover, the analysis can be done in a context of one, two or more periods with or without uncertainty. Although a more complex analysis can provide more sophisticated insights, a more simple analysis can be more intuitive.

There is not a literature very abundant about this topic. However, we can cite the work of De Janvry *et al.* (2002), in which a one-period model without uncertainty is formulated incorporating the credit constraint in it. Guirkinger and Boucher (2006) develop a one-period model with uncertainty taking into account the credit constraint. From an intertemporal perspective, Feder *et al.* (1990) and Petrick (2004) develop a model with credit constraint, with the hired labor and the fertilizers being the variable inputs affected by the credit constraint in each model, respectively. In structure, both models are the same; however, Feder et *al.* (1990) additionally consider the variable investment in the analysis. Thus, when the credit is not constrained, the household maximizes the utility function based on the decisions of hired labor, investment, and credit in period one. Finally, De Janvry and Sadoulet (2006) formulate a general model where credit constraint would be a particular case.

For its simplicity, we followed Petrick's (2004) approach; however, we took some considerations from Feder *et al.* (1990) and directly used the equilibrium conditions to interpret the non-separability in the household's consumption and production decisions in the context of credit constraint.

The starting point is a neoclassical producer-consumer model in a static context of two-period. The household should maximize its utility based on the consumption of goods in this season, $C_0$, and in the next season, $C_1$. We assume an additive utility function that is twice differentiable and quasi-concave, which is defined for a fixed value of household characteristics ($z^h$), for example, family size or number of dependents. Thus, we have the following utility function

$$U = U(C_0, C_1, z^h) \quad U' > 0\ ;\ U'' < 0$$

In this simple model, the consumption in the next period depends on the decisions of production taken today and, therefore, the agricultural production requires financing one period ahead through buying the variable input needed to produce, $x$ (for example, fertilizer or seeds). Thus, the production opportunities of the household are represented by a twice differentiable, concave production function $y=f(x, z^y)$ ($f_x>0$ *and* $f_{xx}<0$), the price of $x$ is $P$, and $z^y$ presents fixed and exogenous inputs such as capital stock, land, and family labor force. Thus, the expenditures in the present are consumption $C_0$ and variable inputs, $x$, which depend on an initial endowment of the household's liquidity, E, and Credit, K, which has a price of $r$. On the other hand, the expenditures in the second period would be consumption, $C_1$ and payment of the credit (1+$r$) K, which would be financed with the production. For simplicity we normalized all the prices with the price of $y$. Moreover, we assume an upper limit of credit, $K^{up}$, in order to take into account the possibility of facing credit constraint, $K^{up}$ ($z^h$ $z^y$), which depends on $z^h$ and $z^y$. Note that if the constraint is not binding, then K is lower than $K^u$ and is endogenous in the system.

Thus, the household's problem can be formulated as follows

$$\text{Max } U = U(C_0, C_1, z^h)$$

*sa.*

$$C_{0,} = E + K - p\,x \tag{1}$$

$$C_1 = f(x, z^y) - (1+r)\,K \tag{2}$$

$$K^{up}(z^h z^y) \leq K \tag{3}$$

Replacing (1) and (2) directly in the utility function and assuming that the credit constraint is not binding, we have

$$\underset{x,\,K}{\text{Max}}\ U = U(E + K - p\,x\,,\, f(x, z^y) - (1+r)\,K\,, z^h)$$

The first-order conditions are

$$x; \quad \frac{U'(c_0)}{U'(c_1)} = \frac{f_x}{p} \tag{4}$$

$$K; \quad \frac{U'(c_0)}{U'(c_1)} = (1+r) \tag{5}$$

From (4) and (5), we have

$$\frac{U'(c_0)}{U'(c_1)} = \frac{f_x}{p} = (1+r) \tag{6}$$

The optimal consumption and production decisions are defined for conditions (7) and (8)

$$\frac{U'(c_0)}{U'(c_1)} = (1+r) \tag{7}$$

$$f_x = p(1+r) \tag{8}$$

Condition (7) suggests that the marginal rate of utility substitution between consumption in periods 0 and 1 should be equal to relative price of consuming, which in equilibrium is equal to one plus the market interest rate. Condition (8) suggests that the marginal return on productive investment equals the marginal cost adjusted by the market interest rate. Clearly, those equilibrium conditions satisfy the condition of separability in the household model. Thus, if there is not a binding credit constraint, the reduced-form output supply function, *y*, could be expressed as

$$y = G(x(p, r, E), z^y) = G(p, r, E, z^y) \tag{9}$$

Now, if we assume that the amount of credit wanted is higher than the upper limit $K^{up}$, then we have to maximize the objective function using the Kuhn-Tucker conditions, taking λ as the marginal value of the constraint. Thus, the problem to maximize would be

$$\underset{x,\,K}{\text{Max}}\; U = U\,(E + K - p\,x\,,\, f(x, z^y) - (1+r)\,K\,, z^h) + \lambda\,(K^{up}\,(z^h\, z^y) - K)$$

The first-order conditions for an interior solution are

$$\text{x;} \qquad \frac{U'(c_0)}{U'(c_1)} = \frac{f_x}{p} \tag{10}$$

$$\text{K;} \qquad \frac{U'(c_0)}{U'(c_1)} = (1+r) + \frac{\lambda}{U'(c_1)} \tag{11}$$

From (10) and (11), we have

$$\frac{U'(c_0)}{U'(c_1)} = \frac{f_x}{p} = \left[ (1+r) + \frac{\lambda(z^h, z^y)}{U'(c_1)\big|_{z^h}} \right] \tag{12}$$

The optimal consumption and production decisions are defined for conditions (13) and (14)

$$\frac{U'(c_0)}{U'(c_1)} = \left[ 1 + r + \frac{\lambda(z^h, z^y)}{U'(c_1)\big|_{z^h}} \right] \tag{13}$$

$$f_x = p\left[ 1 + \underbrace{r + \frac{\lambda(z^h, z^y)}{U'(c_1)\big|_{z^h}}}_{\textit{Shadow Price}\ \textbf{(SP)}} \right] \tag{14}$$

With a binding credit constraint, we have to change the relevant interest rate. Focusing on condition (14), we can see that the *shadow price* (SP) of the variable input increases because $\lambda$ and $U'$ are positive, which demonstrates that with binding credit constraint the production, $y$, is lower because the demand for $x$ is lower. Clearly, the equilibrium conditions (13) and (14) show that with binding credit constraint the condition of separability is broken in the household model, because both the consumption and production decisions are mutually connected.

For example, taking the expression (14) to see what happens with the variable input demand, an increased family size ($z^h$) would affect both $\lambda$ and $U'(c_1)$, and the final effect would depend on how we previously modeled this kind of interaction. Thus, if we assume that an increased family size increases the consumption in each period, then the marginal utility of $c_1$ decreases, increasing the shadow price of the input. On the other hand, if the lender believes that a higher family size involves less risk to lending, this would cause $K^{up}$ to increase, relaxing the credit constraint and the shadow price. Then, the net effect is not clear because each effect acts in the opposite direction[3]. Note that if the credit constraint is strongly relaxed we have the case that $\lambda$ tends to zero and we would go back to the situation where the credit constraint is not binding (8).

Thus, if the credit constraint is binding, the reduced-form output supply function, $y$, can be expressed as

$$y= G(x(p, r, E ,K, z^h), z^y)= G(p, r, E, K, z^h, z^y) \tag{15}$$

The key point in this context is that the reduced-form output supply function should only depend on the exogenous variables. Thus, any input that depends on the amount of liquidity in the period zero should not appear in the reduced-form output supply function. Additionally, it should be clear that given the model structure one additional unit of liquidity (Credit) could be spent partially on production and the rest could be used in consumption.

---

[3] Petrick (2004) presents a similar result. However, he derives it by taking the constraint of the first period (present) and calculates the implicit differentiation for the variables $z^h$ and shadow price of interest rate (SP). He justifies this procedure based on Benjamin (1992), who uses only one period (present). From my point of view, Petrick should have taken not only the constraint in the present, but also the constraint in the future because the shadow price will be determined as a result of an intertemporal equilibrium (present and future). This presentation directly uses the equilibrium conditions to analyze this issue.

Based on this framework, the *hypothesis of Liquidity* (HL) is defined as a situation in which the constrained household production depends on the amount of credit that it can get, and also of the characteristics of the demand side, such as preferences. This does not happen for the unconstrained households. In other words, if this hypothesis can not be rejected, we will have evidence of non-separability of the household decisions. Finally, in order to test this hypothesis, in the Chapter VII we will use expressions (9) for the unconstrained farmers and (15) for the constrained.

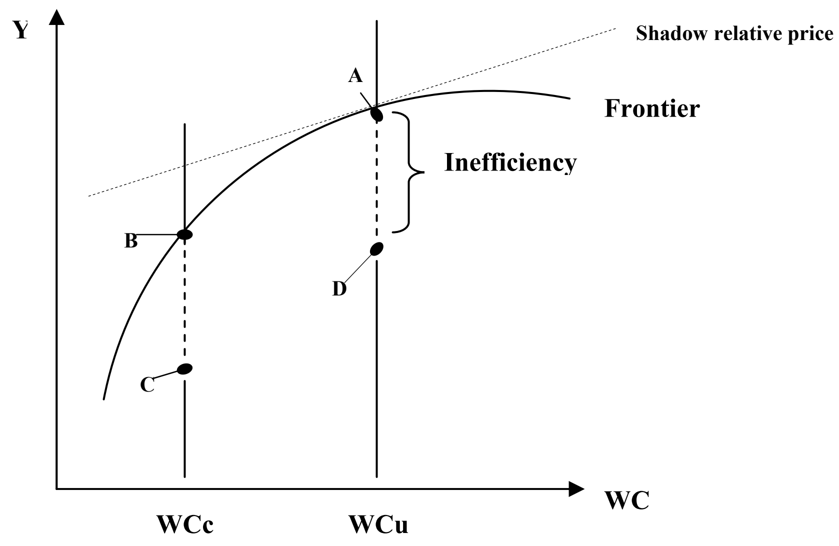
### 3.1.2 Credit constraint and Efficiency

There is not empirical evidence that provides theoretical explanations for the expected relation between technical efficiency and credit constraint. The constrained condition is more related to the availability of inputs than its use. We can see in **Figure 4** that given a certain level of shadow relative prices[4], which is expressed by the discontinuous line in the figure, and assuming technical efficiency, the absence of constraint (WCu, working capital unconstrained) would drive a farm to point A. However, the farm could equally be located at point D due to the inefficient use of the inputs.

On the other hand, if the farm were constrained (WCc, working capital constrained), the level of inputs used would be lower, but again, the farm could be located either at point C or B. What kind of motivations are behind the farmers to be more or less efficient when they are constrained?. We could think that farmers would have more incentives to reach their goal when they are constrained. But, at the same time, constrained farmers are expected to have more difficulties to get the optimal input mix and, therefore, would be less efficient.

[4] The graphic assumes that if there is credit constraint, the shadow relative price incorporates it.

**Figure 4**
**Efficiency and Credit Constraint**




### 3.1.3 Off-farm activities at household

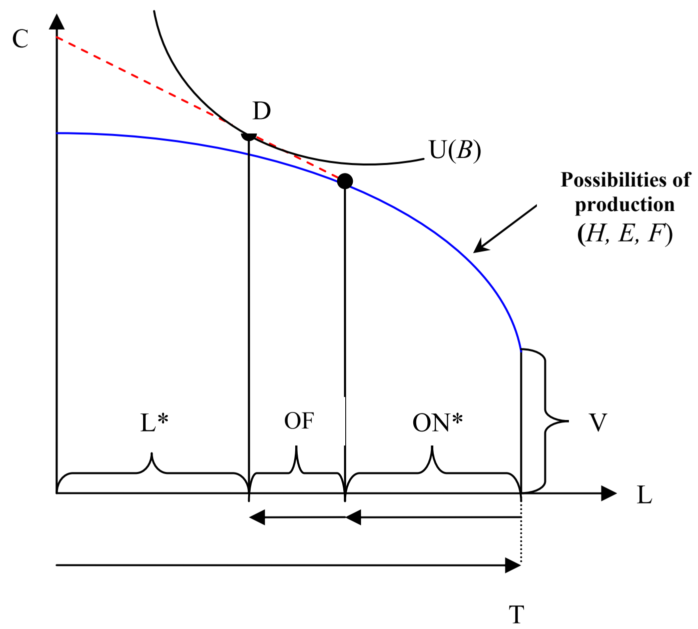
Following Howard and Swidinsky (2000), a standard model suggests that a single family has to make decisions about leisure (L) and consumption of goods (C), but there exists a trade-off in this kind of decision, because a household sacrifices leisure to consume goods and vice versa, which is represented by the indifference curve, U. The slope of U is the marginal rate of substitution between leisure and consumption, which may be written as MRS = F(C, L: G) where G is a set of exogenous characteristics that determine preferences, such as age and education of the head family and the number of children. However, the combinations of good and leisure units that a household can access, at a given indifference curve such as U, are limited by fourth kind of restrictions.

First, the available total time of leisure (T) could be divided in three uses: leisure, work on-farm (ON) and work off-farm (OF). Second, an exogenous income endowment to the labor effort (*V*), such as subsidies from the government and pensions, that permits to consume certain amount of goods without necessity of labor (on and off farm). Third, on-farm income produced for the production function of each family Q = F(ON, X*; H, E, F*). Thus, using part of leisure to work on farm, and mixing it with other inputs X, it is possible to produce a certain level of production given certain human capital characteristics, *H*, farm characteristics, *E*, and family characteristics, *F*. The slope of this constraint represents the marginal product of farmer labor, which is decreasing because of fixed factors in the production. The family will reach the optimal level of supply labor on farm (ON*) when the marginal returns to labor is equal to the farm wage (Wf). Fourth, if the family works off-farm, they can get an income equals to the number of hours worked off-farm multiplied by the off-farm wage rate (Woff).

Thus, family has to maximize the utility function Max U (G, L; *B*) given the following constraints Pq * Q(..) + Woff * OF + V = Pg * G + Px * X , and T = L + OF + ON, where Pq, Pg and Px are the prices of goods produced, goods consumed and inputs used for the farmers, respectively.

Using **Figure 5**, the optimum allocation between goods and leisure units occurs at the equilibrium point D where the highest attainable curve is tangent to the four constraints mentioned. At point D the marginal rate of substitution between the consumption of goods and leisure activities is equal to the farm and off-farm wage rates. Therefore, the household allocates time such that ON, OF and L units are spent on farm and off-farm work and leisure, respectively.

**Figure 5**
**Household's decisions to participate in off-farm activities**




Based on the relevant reservation wage (WR) of the leisure-good model, the *participation rule* adopted by the members of the family would be:

*Accept off-farm work when*

MRS ≤ Wf (Evaluated at the time worked on farm) ≤ WR

*Reject off-farm work when,*

MRS > Wf (Evaluated at the time worked on farm) > WR

Assuming "*separability"* in the decisions of production and consumption of the household, the off-farm labor supply is obtained by the difference between the available total leisure and the sum of optimum on-farm work and leisure OF* = T – ON* – L* = OF (Woff, Pq, Px, Pg, *B*, *H, E, F, V*). Then, given little variation in prices and available time, off-farm labor supply can be modeled as a function of market wages, human capital, farm and family characteristics, other income and the variables that determine the preferences.

OF* = OF (Woff, *H, E, F, V, G*)

Additionally, it is possible to define the formation of wages, Woff = Woff (*H, M*), depending on human capital characteristics, *H*, and labor market conditions, *M*. According to this formulation, it is possible to clearly see the variables that are behind the estimation of both an equation of participation and an off-farm labor supply. In Chapter VI this framework will be the starting point to model the binary behavior of the household decisions to participate in off-farm activities by estimating a Probit model.

### 3.1.4 Empirical applications concerning the Off-farm activities

Based on the conceptual framework developed, the empirical literature has basically focused on two lines of research with some extensions. First, estimations of the off-farm labor supply (Huffman, 1980; Sumner, 1982; Furtan *et al.*, 1985; Sahn and Alderman, 1988; Lass *et al*, 1989; Gould and Saupe, 1989; Mishra and Goodwin, 1997; Weersink *et al.*, 1998; Abdulai and Delgado, 1999; Howard and Swidinsky, 2000; and Serra *et al.*, 2003). Second, some papers have studied the determinants of participation in off-farm labor, where the emphasis has been on the role of the spouse's or other family member's decision-making (Huffman and Lange, 1989; Gould and Saupe, 1989; Lass *et al.*, 1989; Findeis, 1992; Kimhi, 1994; Huffman and El-Osta, 1997; Lass and Gempesaw, 1992; Tokle and Huffman, 1991; Kimhi, 2004; Kwon *et al.*, 2006; and Benjamin and Kimhi, 2006).

Some other works have analyzed the impact on the participation decisions of the inclusion of local labor market considerations (Tokle and Huffman, 1991; Gunter and McNamara, 1990; Lass and Gempesaw, 1992; and El-Osta and Ahearn, 1996) and the use of instruments of public policy (Ahearn *et al*, 2006; and Key *et al.* 2006).

## 3.2 Efficiency Analysis

### 3.2.1 Measuring Technical Efficiency: Stochastic Frontier Analysis (SFA)

From the seminal work of Farrell (1957) many developments have been made in the analysis of the efficiency concept, however, understanding it as the ratio between the effective product[5] and the potential product (frontier). Thus, the basic idea is to estimate or calculate the frontier from the available data. Two working lines have basically been followed to do so: the parametric methods, divided into deterministic and stochastic, whose characteristic is the definition ex ante of a functional form of the efficient frontier, and the non-parametric methods, where a functional form is not required and the frontier is calculated in an empirical way from the sample observations[6].

The problem with the deterministic parametric and non-parametric approaches is that they assume that all deviations from the efficient frontier are inefficiency. However, it is possible to find plausible reasons to understand that it should not always be considered as inefficiency. It is possible to have errors in the observations and in the measurement of outputs and/or to have factors out of the control of the farmers (for example in agriculture) such as weather, uncertainty, diseases, socio-economic factors and demographic factors that could be explaining those departures, but they are not efficiency at all. An advantage of stochastic

[5] In this case we are interested in technical efficiency so the variable of interest is production or value of production. On the other hand, if we were concerned with economic efficiency, it would be necessary to use the profit variable. Finally, if we want to estimate the allocative efficiency, we need to use the cost function instead of production data; however, in that case, the inefficiency would be defined as the ratio between frontier cost and current cost

[6] A very good revision is fund in Kalirajan and Shand (1999) and Murillo-Zamorano (2004). A more advanced treatment is found in Coelli *et al.* (1998) and Kumbhakar and Lovell (2000).

frontier analysis is that various hypotheses concerning modeling the technology can be statistically tested and the modeled technology can follow some theoretical base in conformity with the production theory.

The *stochastic frontier procedures* explicitly consider two types of departures from the frontier by introducing a double-sided random error into the model specification. One is justified by specification failures and uncontrollable factors, which are represented by the term v, and the inefficiency component, which is represents by the term u. Aigner *et al.* (1977), Meeusen and van den Broeck (1977) and Battese and Corra (1977) simultaneously developed a Stochastic Frontier Model. A simple representation of such a model is given by

$$y_i = f(x_{ik})\ exp(v_i - u_i) \qquad (1)^7$$

where $y_i$ denotes the level of output for observation $i$, $x_{ik}$ denotes the k inputs, f(·) denotes the frontier production function and $v_i - u_i$ is a composted error that we define as $w_i$. Note that only $w_i = v_i - u_i$ can be observed, which is why distributional assumptions are required for $v_i$ and $u_i$. Thus, it is assumed that $v_i$ is a pure random term (white noise) *i.i.d* and $u_i$ is a systematic, nonnegative error term accounting for efficiency.

With the assumption that $u_i$ is non negative a numbers of density functions can be specified for u such as half-normal, exponential and gamma; however, the half-normal distribution has dominated the empirical literature of Stochastic Frontier Analysis (SFA)[8]. Thus, if the two error terms are assumed independent of each other and one of the above distributions is used, we can estimate the frontier. To do that, it is possible to use OLS. However, this technique is inappropriate because it deals with the identification of average relationships, which is not in the focus of an efficiency model. That is why maximum likelihood estimates are more commonly used[9].

7 Note that this formulation corresponds to an output-oriented efficiency measurement and the technical efficiency measure is $TE_i = exp(-u_i) \in [0,1]$. Alternatively, the inverse of $TE_i$ gives the maximum expansion of the output level without changing the level of inputs.

8 Battese and Coelli (1988 and 1992) tested normal-half normal models against normal-truncated models and frequently the latter have not rejected the former.

9 An alternative approach for the estimation of all parameters involved in the stochastic model invokes the use of the “method of moments”. Olson *et al.* (1980) describe such a technique in a normal-half normal framework.

Jondrow *et al.* (1982) separate the composed error term and get a measure of inefficiency at economic unit level both for a half-normal and for an exponential distribution[10]. On the other hand, Horrace and Schmidt (1996) created confidence intervals for technical efficiency point estimates and derive upper and lower bounds for the levels of estimated efficiency[11].

### 3.2.2 Modeling Technical Efficiency

Kumbhakar and Lowell (2000) present a comprehensive discussion concerning how the study of the effects of exogenous variables on firms' levels of technical efficiency has evolved, showing the main approaches used to explain the influence of external factors on the efficiency.

Following Wang and Schmidt (2002), we present a simple model of technical efficiency. Let $y_i$ be log output; let $x_i$ be a vector of variables that affect the position of the frontier; and let $z_i$ be a vector of variables that affect the magnitude of technical inefficiency. Generally the $x_i$ are inputs and the $z_i$ are either functions of inputs or measures of the environment in which the firm operates. The $x_i$ and $z_i$ can overlap. Because the $z_i$ (like the $x_i$) are treated as fixed, they cannot be functions of $y_i$

Let $y_i^* \geq y_i$ be the unobserved frontier. The linear stochastic frontier model asserts that, conditional on $x_i$ and $z_i$, $y_i^*$ is distributed as $N(x_i\beta, \sigma^2_v)$. Then we can write the frontier as:

$$y_i^* = x_i\beta + v_i \qquad (2)$$

where $v_i$ is distributed as $N(0,\sigma^2_v)$ and is independent of $x_i$ and $z_i$. Finally, the model asserts that (conditional on $x_i$ and $z_i$, and $y_i^*$) the actual output level $y_i$ equals $y_i^*$ minus a one-sided error whose distribution depends only on $z_i$. Therefore we can write the model as:

$$y_i = x_i\beta + v_i - u_i\,(z_i,\delta) \qquad , \quad u_i\,(z_i,\delta) \geq 0 \qquad (3)$$

[10] Battese and Coelli (1988) proposed another alternative point estimator for $TE_i$. This is preferred to others when $u_i$ is not close to zero. However, although all those estimators are unbiased, they are not consistent (Schmidt, 1986).

[11] Additionally, Hjalmarsson *et al.* (1996) propose confidence intervals for the Jondrow *et al.* (1982) technical efficiency estimator, and Bera and Sharma (1996) for the Battese and Coelli (1988) estimators.

where $u_i$ and $v_i$ are independent of each other and of $x_i$, and in addition $v_i$ is independent of $z_i$. Many empirical analyses have proceeded in two steps. In the first step, one estimates the stochastic frontier model and the firms' efficiency levels, ignoring the external factors, and in the second step, one tries to see how efficiency levels vary with the external factors by regressing a measure of efficiency on the external variables selected. However, this procedure has problems because the model estimated at the first step is misspecified. In other words, the inefficiency term from the first step is measured with error and the error is correlated with the exogenous factors, the regressors in the second step. Caudill and Ford (1993) and Wang and Schmidt (2002) have provided evidence of the bias of this procedure.

The solution to this bias problem is a one-step procedure. This technique is based on the correctly specified model for the distribution of the product given the inputs of the production function and the external factors that explain the inefficiency. By imposing some type of relationship between the external factors and technical efficiency in only one regression the estimation of the parameters both of technology and inefficiency model are simultaneously estimated. There are three pioneer papers using this technique: Kumbhakar *et al.* (1991), Huang and Liu (1994) and Battese and Coelli (1995). Everyone models the mean of the distribution of the inefficiency and most applications have used the Battese and Coelli's approach. However, other papers have modeled the variance of the inefficiency instead of its mean, such as, Caudill and Ford (1993), Caudill *et al.* (1995) and Hadri (1999) and there are a few applications incorporating heteroscedasticity in the frontier estimations.

Caudill and Ford (1993) have shown in the context of a Monte-Carlo study that heteroscedasticity can lead to biased estimates in frontier analysis. Caudill *et al.* (1995) developed an extension of a stochastic frontier cost function model for cross-sectional data to consider the relationship between an individual farm's residual variance and farm size.

Caudill *et al.* (1995) analyze the heteroscedasticity as a specification bias in the production functions and claim that the one-sided error term embodies factors under firm control and larger firms have more under their control. They model the heteroscedasticity of the inefficiency term by considering two assumptions: the inefficiency follows a multiplicative heteroscedasticity (Greene, 1990) and a precise knowledge of the functional form of the heteroscedasticity for the estimation is not necessary. On this point, they assume that some properties of linear models hold to nonlinear models (Kennedy, 1985). They use (3), assuming that $u_i\ (z_i,\delta)$ follows a half-normal distribution, $N(0,\sigma^2_{ui})^+$, and

$$\sigma_{ui} = \exp(z_i{'}\delta) \qquad (4)$$

where $z_i$ is a vector of variables related to firm size (include an intercept) and $\delta$ is a vector of unknown parameters. Following Brummer and Loy (2000), if the standard deviation of the non-systematic error $v$ is also written in exponential form as $\sigma_v = \exp\ \Omega$ then the Log-Likelihood Function (LLF) can be expressed as

$$\text{LLF} = \ln L_i(\beta, \sigma_i(\delta,\Omega), \lambda_i(\delta,\Omega)) = \ln\frac{2}{\sqrt{2\pi}} - \ln\sigma_i - \frac{w_i^2}{2\sigma_i^2} + \ln\phi(-\frac{\lambda_i}{\sigma_i}w_i) \qquad (5)$$

where $\sigma_i(\delta,\Omega) = \sqrt{\exp(2z_i\delta + 2\Omega)}$ , $\lambda_i(\delta,\Omega) = \exp(z_i\delta - \Omega)$ and $\phi$ is the cumulative density function.

From all those developments, Wang and Schmidt (2002) and Alvarez *et al.* (2006) have advanced in analyzing the model selection and its implications for estimation results. Particularly, Wang and Schmidt (2002) provide some arguments in favor of models that satisfy a certain type of property (*scaling property*) because they basically facilitate the estimations and interpretations of the regressions.

Using (3), Wang and Schmidt (2002) define *scaling property* as

$$u_i\ (z_{i,}\delta) = h\ (z_{i,}\delta) \bullet u_i{*} \qquad (6)$$

where $h\ (z_{i,}\delta) \geq 0$, and where $u_i{*} \geq 0$ has a distribution that does not depend on $z_i$. We will call $h\ (z_{i,}\delta)$ the *scaling function* and $u_i{*}$ the *basic random variable*, while the distribution of $u_i{*}$ will be called the *basic distribution*[12].

Wang and Schmidt (2002) claim that the essential feature of the scaling property is the fact that changes in $z_i$ change the scale but not the shape of the distribution of $u_i$. This is so because the shape is determined by the basic distribution, which does not depend on $z_i$,

[12] The scaling property corresponds to a multiplicative decomposition of $u_i(z_{i,}\delta)$ into these two independent parts A different alternative of modeling considers an additive decomposition of $u_i(z_{i,}\delta)$ (Huang and Liu, 1994; Battese and Coelli, 1995; and Simar and Wilson, 2003), however, it does not satisfy the scaling property.

whereas the scaling function $h(z_{i,}\delta)$ determines the scale. On the other hand, the interpretation of $\delta$ does not depend on the distribution of inefficiency, and simple scaling functions yield simple expressions for the effect of the $z_i$ on mean efficiency.

On the other hand, Alvarez *et al.* (2006) show how to test the hypothesis of scaling among different models by using LR, LM and Wald tests, finding evidence in favor of the approaches that model the variance of the inefficiency term instead of its mean.

### 3.2.3 Empirical applications: Modeling the variance of the inefficiency term

As mentioned, the works of Wang (2002) and Alvarez *et al.* (2006) used data from the agricultural sector to show their methodological findings with regard to the selection model in efficiency analysis. However, there are a few papers that have modeled the variance of the inefficiency term in the agricultural sector. Brummer and Loy (2000) studied the impact of a credit program on the technical efficiency of a panel of dairy farmers in Germany, showing that such a program had not contributed to increase efficiency of their participants. Hadri *et al.* (2003) used panel data of 102 cereal farms in England to estimate technical efficiency, demonstrating that the correction for heteroscedasticity is essential to obtaining valid estimates. Curtiss *et al.* (2005) used a distance frontier approach to analyze the effect of the organizational legitimacy on the technical efficiency of farms of both crop and livestock production in the Czech Republic. Their results support the idea that legitimacy efforts increase the technical efficiency. Weaver *et al.* (2005) studied the relationship between distinct types of GM technologies and technical efficiency in soybean production with 125 observations in Pennsylvania, USA. They found important differences among technologies, remarking that genetically modified technologies may offer important opportunities to alter the impact of agriculture on the environment.

### 3.2.4 Empirical applications: Technical efficiency and Credit Market

According to **Table 4,** a few studies have analyzed the relation between technical efficiency and the credit market. Most of the studies analyze the impact of the financial exposure, measured as the debt-asset ratio, on technical efficiency; however, there are not papers that have studied the simultaneous relation between credit and credit constraint on technical efficiency

The relation between credit constraint and efficiency has been studied lightly. Battese and Broca (1997) studied the importance of the choice of functional forms in the study of efficiency and modeled the mean inefficiency as a function of credit constraint by using a dummy variable (taking the value of 1 when a farm is constrained). The parameter estimate was significant and positive, indicating a negative relation between credit constraint and efficiency. Yanyan (2005) and Hazarika and Alwang (2003) incorporated the variable of credit constraint in their estimations but it was not significant. Those papers do not provide a clear theoretical justification to interpret the parameter estimates.

Another issue is the potential endogeneity of the variables related to credit and efficiency. Davidova and Latruffe (2003) analyzed the endogeneity of financial variables by using a non parametric approach, which forced them to use a two-step procedure with the already mentioned problems of using this kind of technique. Liu and Zhuang (2000), with an approximation stochastic, investigated the impact of liquidity, measured as the sum of available financial resources, on technical efficiency. Although the endogeneity was not tested, they replaced the variable of liquidity by its predicted values, which were obtained from an auxiliary regression of the variable of liquidity on a group of instruments. Habib and Ljungqvist (2005), in the finance field, studied the relation between the shortfall in market value of a firm, interpreted as inefficiency, and some variables related to incentives of managers. After checking for endogeneity, they could not reject the null hypothesis of no endogeneity of the variables studied. Finally, most of the studies consulted do not take into account small farmers probably because of the unreliable quality and availability of information of their liabilities and assets.

In relation to the significance and sign of the parameters estimated, the last column of **Table 4** shows that when the variable related to the credit market is significant, its sign in some cases is positive, indicating a positive relation with efficiency, and in others negative, indicating an inverse relation. In the cases where financial exposure has been studied, some preliminary explanations have arisen, which are summarized in Hadley *et al.* (2001). Basically, three approaches could help us to understand a positive relation between financial exposure and technical efficiency.

First, the theory of Free Cash Flow, based on corporate finance and agency cost, asserts that large asset holdings and excess cash flows could encourage the lack of discipline in management, which would generate technical inefficiency (Jensen, 1986). This approach clearly has some problems because this behavior is expected to exist when there is a difference between ownership and management, which apparently is not the case in smallholders.

Second, the theory of Credit Evaluation suggests that agricultural lenders (formal and/or informal) may partly base their credit evaluations on performance measures of firms; thus, inefficient firms would have a bad evaluation, decreasing their possibilities of getting credit. The problem with this view is that, by definition, simultaneity would exist because the levels of credit would depend on the level of efficiency.

Third, the approach of Embodied Capital claims that during periods of growing, the production frontier tends to shift upwards over time as a result of technical change. If credit is the way to finance capital or another input that contributes to growing, then higher levels of credit would help firms to get higher levels of technical efficiency. The main problem with this approach is that it assumes that credit is the more direct and inexpensive way to finance capital; however, one of the most important problems of small firms is the lack of long-term financing.

On the other hand, there are two theories to explain a negative relation between debt-asset ratio and efficiency. First, the theory of Agency Cost asserts that due to the asymmetric information between lenders and borrowers, lenders cover their uncertainty by transferring higher costs to the clients by means of higher interest rates, higher collateral requirements, etc. Thus, more indebted farmers are probably less inefficient. The weakness of this approach is that it directly assumes that higher debt implies higher inefficiency; however, it is perfectly possible to think about it in the opposite way, particularly when we deal with small farmers who have little access to capital market. Second, the theory of Adjustment proposes that firms in adjustment process are forced to be more efficient in order to survive, so farms with lower debt-asset ratio would be able to make adjustments more easily and would become more efficient. This approach could help us understand the dynamic of the changes in efficiency from two different economic regimes. However, when a stable period is studied, it would not make sense to use such an approach.

In another line of research, Liu and Zhuang (2000) argue, based on Mukesh and Ashok (1989), that credit, given its nature of insurance, could have a positive impact on the technical efficiency for small farmers. Credit is necessary to encourage technical innovation but small farmers could be indifferent to adopt it because of their risk attitudes. If the farmers are adverse-risk, the credit could mitigate the risk of innovations, encouraging innovations and promoting technical efficiency. We believe that this approach is more suitable for framers in subsistence levels with a landholding per household very small, where the uncertainty basically is in the consumption. Proof of this is that in the Liu and Zhuang (2000) study the mean landholding per household is just 0.33 hectare.

## Table 4
## Studies related to efficiency and credit market

| Deterministic Approach | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Authors and year** | **Journal or Conference** | **Title** | **Credit market as a variable of the inefficiency** | | | | | |
| | | | **Constraint** | | **Amount of credit in the short-run** | | | **Is Significant in the short run?** |
| | | | **Dummy** | **Another** | **Level** | **Ratio** | **Dummy** | |
| Chavas J-P and M. Aliber (1993) | Journal of Agricultural and Resource Economics | An Analysis of Economic Efficiency in Agriculture: A Nonparametric Approach | | | | **X** | | No |
| Nasr *et al.* (1998) | Agricultural Finance Review | Financial Structure and Efficiency of Grain Farms | | | | **X** | | Yes (+) |
| Binam e*t al.* (2003) | R&D Management | Factors Affecting technical efficiency among coffee farmers in Cote dIvoire: Evidence from Centre West Region | | | | | **X** | No |
| Davidova and Latruffe (2003) | Work paper in Rennes INRA | Technical efficiency and farm financial management en the countries in transition | | | | X<br>Checked endogeneity | | Yes (+)<br>*Without correction the parameter was not significant* |
| Volodymyrovych V. (2003) | Thesis in North Dakota State University | Evaluation of north Dakota farm production efficiency and financial performance over time | | | | **X** | | Yes (-) |
| Bezlepkina *et al.* (2004) | Agricultural transformation: Lessons from five transition countries | Effects of debt on Moscow-region dairy farm performance: 1996-2000 | | | | **X** | | No, Short term<br>Yes, Long term (+) |
| Chavas *et al.* (2005) | American Journal of Agricultural Economic | Farm household production efficiency: Evidence from the Gambia | | | **X** | | | Yes (-) |
| Blancard *et al.*(2006) | American Journal of Agricultural Economic | Short and long-run credit constraints in French agriculture: A directional distance function framework using expenditure-constrained profit functions | | | | **X** | | No |

| Stochastic Approach | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Authors and year** | **Journal or Conference** | **Title** | **Credit market as a variable of the inefficiency** | | | | | |
| | | | **Constraint** | | **Amount of credit in the short-run** | | | **Significant?** |
| | | | **Dummy** | **Another** | **Level** | **Ratio** | **Dummy** | |
| Mubarik and Flinn (1989) | American Journal of Agricultural Economics | Profit Efficiency among Basmati Rice Producers in Pakistan Punjab | | | | | **X** | Yes (+) |
| Parikh *et al.* (1995) | American Journal of Agricultural Economics | Measurement of Economic Efficiency in Pakistani Agriculture | | | **X** | | | Yes (+) |
| Battese and Broca (1997) | Journal of Productivity Analysis | Functional Forms of Stochastic Frontier Production Functions and Models for Technical Inefficiency Effects: A Comparative Study for Wheat Farmers in Pakistan | **X** | | | | | Yes (-) |
| Sotnikov S (1998) | European Review of Agricultural Economics | Evaluating the effects of price and trade liberalization on the technical efficiency of agricultural production in a transition economy: The case of Russia | | | | **X** | | Yes (-) |
| O'Neill *et al.*(2000) | PhD dissertation in the Department of Economics, Trinity College | Measuring Productivity Change and Efficiency on Irish Farms | | | | **X** | | Yes (+) |
| Morrison *et al. (*2000) | The Review of Economic and Statistics | Efficiency in New Zealand Sheep and Beef farming: The impact of regulatory reform | | | | **X** | | Yes (-) |
| Liu and Zhuang (2000) | Journal of Comparative Economics | Determinants of Technical Efficiency in Post-Collective Chinese Agriculture: Evidence from Farm-Level Data | | | X | | | Yes (+) *Without checking endogeneity they used the fitted values (from two-stage least squares) as instruments* |
| Puig-Junoy and Argilés (2000) | Depart Economics and Business, Pompeu Fabra University | Measuring and explaining farm inefficiency in a panel data set of mixed farms | | | | **X** | | No |
| Abdulai and Huffman (2000) | Economic Development and Cultural Change | Structural Adjustment and Economic Efficiency of Rice Farmers in Northern Ghana | | | | | X | Yes (+) |
| Coelli *et al. (*2001) | Annual meeting of the American AEA | Financial exposure and farm efficiency: Evidence from the England and Wales dairy sector | | | | **X** | | Yes (-) |
| O'Neill and Matthews (2001) | The Economic and Social Review | Technical Change and Efficiency in Irish Agriculture | | | | **X** | | Yes (+) |
| Giannakas *et al.* (2001) | Canadian Journal of Agricultural Economics | Technical Efficiency, Technological Change and Output Growth of Wheat Farms in Saskatchewan | | | | **X** | | Yes (+) |

| Stochastic Approach | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Authors and year** | **Journal or Conference** | **Title** | **Credit market as a variable of the inefficiency** | | | | | |
| | | | **Constraint** | | **Amount of credit in the short-run** | | | **Significant?** |
| | | | **Dummy** | **Another** | **Level** | **Ratio** | **Dummy** | |
| Alene and Hassan (2003) | Interl. Conf. of Agri. Economists, South Africa | Measuring the Impact of Ethiopia's New Extension Program on the Productive Efficiency of Farmers | | | **X** | | | Yes (+) |
| Hazarika and Alwang (2003) | Agricultural Economics | Access to credit, plot size and cost inefficiency among smallholder tobacco cultivators in Malawi | | **X** **Credit limit** | | | | No |
| Binam *et al.* (2004) | Food Policy | Technical, Economic and Allocative Efficiency in Peasant Farming: Evidence from the Slash and Burn Agriculture Zone of Cameroon | | | | | **X** | Yes (+) |
| Battese *et al.* (2005) | Conference. Australian Agri & Resource E Society | The Impact of Rural Financial Services on the Technical Efficiency of Rice Farmers in the Upper North of Thailand1 | | | **X** | | | Yes (+) |
| Karagiannisa and Sarrisb (2005) | Agricultural Economics | Measuring and explaining scale efficiency with the parametric approach: The case of Greek tobacco growers | | | **X** | | | Yes (-) |
| Karagiannis and Tzouvelekas (2005) | European Review of Agricultural Economics | Explaining output growth with a heteroscedastic non-neutral production frontier The case of sheep farms in Greece | | | **X** | | | Yes (+) |
| Liu Y (2005) | Thesis Department of Economics, Michigan State University | Model Selection and Implications in Stochastic Frontier Analysis: Maize Production in Kenya | **X** | | | | | No |
| Zavale *et al.* (2005) | Paper Department of Applied Economics Cornell University | Smallholders' Cost Efficiency in Mozambique: Implications for Improved Maize Seed Adoption | | | | | **X** | Yes (+) |
| Habib and Ljungqvist (2005) | Journal of Business | Firm Value and Managerial Incentives: A Stochastic Frontier Approach | | | | | | *Tested endogeneity in variables that explain efficiency* |
| Zhengfei and Lansink (2006) | American Journal of Agricultural Economic | The source of productivity growth in Dutch agriculture: A perspective from finance | | | | **X** | | No *Effects on the Productivity Growth* |

Source: Own review

### 3.2.5 Empirical applications: Technical Efficiency and Off-farm activities

Using techniques of relative efficiency such as deterministic and stochastic approaches, there are some papers that have tried to explain the technical efficiency with variables related to off-farm activities, however, there are not conclusive results. **Table 5** summaries the literature and shows that the variable of off-farm activity has been used in different ways. Thus, the variable of off-farm activity has been measured as: dummy variable (taking the value I if farm or household participates in off-farm activities), participation of the off-farm income in the total income, number of hours worked off-farm, levels of off-farm income, logarithms of the levels of off-farm income and the percentage of household member engaged in off-farm activities. In general, using any way to incorporate the off-farm activities, the results are not conclusive, and none has considered endogenous behavior in the variable off-farm activities.

**Table 5**
**Studies related to efficiency and off-farm labor**

| Paper | Year | Measurement | Effect on TE | Significant? |
|---|---|---|---|---|
| *Deterministic Approach* | | | | |
| Chavas P. | 2005 | Participation in the total income | - | No |
| Bayda V. | 2003 | Participation in the total income | - | Yes |
| Coelli, Rahman and Thirtle | 2002 | Participation in the total income | - | No |
| Fernandez-Cornejo | 1994 | Dummy | - | No |
| Chavas and Aliber | 1993 | Participation in the total income | - | No |
| *Stochastic Approach* | | | | |
| Kibaara W | 2005 | Dummy | + | Yes |
| Zavale, Mabaya, and Christy | 2005 | Dummy | - | No |
| Gebreegziabher, Oskam and Woldehanna | 2004 | Dummy | - | Yes |
| Brummer B. | 2001 | Dummy | - | Yes |
| O'Neill and Matthews | 2001 | Dummy | - | Yes |
| O'Neill, Leavy and Matthews | 2000 | Dummy | + | No |
| Ali and Flinn | 1989 | Dummy | - | Yes |
| Pascual U. | 2001 | Hours | - | Yes |
| Abdulai and Huffman | 2000 | Hours | - | Yes |
| Parikh, Ali and Shah | 1995 | Hours | + | Yes |
| Villano and Fleming | 2006 | Levels of income | - | Yes |
| Karagiannis, Tzouvelekas and Xepapadeas | 2003 | Levels of income | + | Yes |
| Arega, Alene and Hassan | 2002 | Levels of income | + | No |
| Kalirajan K | 1990 | Levels of income | + | Yes |
| Tuffa, Heshmati and Oygard | 2005 | Log of income | + | Yes |
| Khairo and Battese | 2000 | Log of income | + | No |
| Singh Bagi | 1984 | Comparison between two groups | - | |
| Liu Y. | 2005 | % HH members in off-farm | + | Yes |
| Rahman S. | 2002 | Participation in the total income | - | Yes |

Source: Own review

In another line of research, Goodwin and Mishra (2004), based on Smith (2002), studied the relationship between farming efficiency and off farm labor supply. They found that a more intensive participation in off-farm labor markets tends to be associated with lower farmer efficiency. They used a simultaneous equation system to determinate the off-farm labor supply and the efficiency, and defined the farm's overall efficiency as gross cash income over total variable cost. The efficiency considered is a measurement of absolute efficiency which does not fix with the definition of efficiency used in most empirical applications at the present. On the other hand, Zeng (2005) analyzed the same issue using a stochastic frontier approach to estimate a score of efficiency, which was used in a Tobit model to explain the off-farm labor supply. His results found a positive relation between off-farm labor supply and efficiency, but the inefficiency was not modeled.

## 3.3 Switching Regression Model (SRM)

We need to find an econometric technique that permits us to deal with two objectives in Chapter VII. On the one side, testing the hypothesis of liquidity (HL) comparing two groups of farmers (constrained and unconstrained), and on the other side, based on the literature of Treatment Effects, measuring the impact of credit and credit constraint on the average production, taking into account the influence of latent and observable characteristics of the farmers. To do that, a switching regression model is used, following Maddala and Nelson (1975), Maddala (1983), and Carter (1989).

### 3.3.1 Conceptual formulation of Switching Regression Models (SRM)

Following Carter (1989), let ***Y*** be the anticipated output supply function what the farmer expects to produce given the prevailing market conditions, resource endowments, and skills. The anticipated values for individual '*i*' are:

$Y_{1i} = \delta' x_i + V_{1i}$ Regime 1: for one sub-sample (constrained or recipient) and (1a)

$Y_{2i} = \beta' x_i + V_{2i}$ Regime 2: for the another sub-sample (unconstrained or non-recipient) (1b)

The $x_i$*'s* represent the observable market conditions, characteristics, and resources and the $V$ captures the returns to individual productivity attributes. The realized functions, $y$, that correspond to equations (1a and 1b) can be written as:

$y_{1i} = \delta' x_i + V_{1i} + \varepsilon_{1i}$ for one sub-sample (constrained or recipient) and (2a)

$y_{2i} = \beta' x_i + V_{2i} + \varepsilon_{2i}$ for the another sub-sample (unconstrained or non-recipient) (2b)

where the random errors ε is the difference between individual *i*'s realized and anticipated output supply, and it is assumed that $E(\varepsilon_i)=0$ for all samples and sub-samples.

Estimating the equations with OLS produces inconsistent estimates, because those equations are omitting a variable that arises from the truncated distribution. The econometric problem is that some unobservable variables of ***y*** are correlated with the error terms. Following Maddala (1983), when the sample separation is observed (constrained and unconstrained or recipients and non-recipients), we can define a dummy variable $D_i$ which equals one, if individual '*i*' belongs to a particular group (constrained credit or with credit) and zero otherwise, and this binary behavior is modeled with the vector of variables $z_i$. Thus, this criterion function splits up the sample in two groups. Thus, $D_i$ can be modeled as the result of a latent variable, $L_i$, which is scaled such that an individual will belong to one group when $L_i > 0$. Formally,

$$\text{Prob}(D = 1 \mid x) = \text{Prob}(L > 0 \mid x) \text{ and} \quad (3a)$$

$$\text{Prob}(D = 0 \mid x) = \text{Prob}(L < 0 \mid x) \quad (3b)$$

A reduced form specification for latent variable can be written as

$$L_i = \gamma' z_i + v_i \quad (4)$$

where $z_i$ is a vector of variables that influence each state, γ is a vector of parameters, and *v* is an error component reflecting random and latent factors that influence the state. Thus, the condition of each state can be written as

$$D = \begin{cases} 1 & \text{if } L_i = \gamma' z_i + v_i > 0 \text{ or } v_i > -\gamma' z_i \\ 0 & \text{Otherwise} \end{cases} \quad (5)$$

Combining equations in (2) and (5), the expected output supply conditional on the each state and observable characteristics is:

$E(y \mid D=1) = \delta' x_i + E(u_{1i} \mid v_i > -\gamma' z_i)$ (6a)

$E(y \mid D=0) = \beta' x_i + E(u_{2i} \mid v_i < -\gamma' z_i)$ (6b)

where conditioning on the xi has been suppressed and $u_{1i} = V_{1i} + \varepsilon_{1i}$ and $u_{2i} = V_{2i} + \varepsilon_{2i}$. Since $E(\varepsilon_i) = 0$, then equations in (6) can be written as:

$E(y \mid D=1) = \delta' x_i + E(V_{1i} \mid v_i > -\gamma' z_i)$ (7a)

$E(y \mid D=0) = \beta' x_i + E(V_{2i} \mid v_i < -\gamma' z_i)$ (7b)

The fundamental econometric problem induced by endogenous status is the lack of information on individual attributes that can affect both the condition of each state and the production. As a second best solution, distributional assumptions can be made to substitute for the latent information. Following the sample selection literature, it is possible to separately identify the effect of latent individual attributes and obtain consistent estimates of the structural parameters of the output supply function conditional on assumptions about the error structure.

The assumption employed here is that ($v_i$, $u_{1i}$, $u_{2i}$) are distributed multivariate normal with zero expectations and positive definite covariance matrix (Maddala, 1983). Thus, the conditional expectations in (7) can be rewritten as:

$E(V_{1i} \mid D=1) = \rho_1 E(v_i \mid D=1) = Cov(v_i, V_{1i})\,\lambda_1$ (8a)

$E(V_{2i} \mid D=0) = \rho_2 E(v_i \mid D=0) = Cov(v_i, V_{2i})\,\lambda_2$ (8b)

where $\lambda_1 = \frac{\phi(c)}{\Phi(c)}$; $\lambda_2 = \frac{\phi(c)}{(1-\Phi(c))}$; $\rho_1\sigma_1\sigma_v = Cov(v, V_1)$ ; $\rho_2\sigma_2\sigma_v = Cov(v, V_2)$ and $c = \frac{\gamma' z}{\sigma_v^2}$

and $\phi(c)$ and $\Phi(c)$ are the standard normal density and cumulative density functions, respectively, defined over the observable variables that determine each state. However, if we assume that $\sigma_v^2 = 1$ then we have

$E(V_{1i} \mid D=1) = \rho_1 E(v_i \mid D=1) = (\rho_1\sigma_1)\,\lambda_1$ (8a')

$E(V_{2i} \mid D=0) = \rho_2 E(v_i \mid D=0) = (\rho_2\sigma_2)\,\lambda_2$ (8b')

Note that the ($\rho\sigma$) are the population regression coefficients relating the V to $\nu$ and the $\lambda$ are the estimates of $\nu$ given each state.

Given these specifications, the complete endogenous switching regressions model becomes

$$D = \begin{cases} 1 & \text{if} \quad \nu_i > -\gamma' z_i \quad \text{for the constrained credit or recipients of credit} \\ 0 & \text{Otherwise} \end{cases} \tag{9a}$$

$$y_{1i} = \delta' x_i + (\rho_1\sigma_1)\, \lambda_{1i} + \tau_{1i} \qquad \text{for the constrained credit or recipients of credit} \tag{9b}$$

$$y_{2i} = \beta' x_i + (\rho_2\sigma_2)\, \lambda_{2i} + \tau_{2i} \qquad \text{for the unconstrained credit or non-recipient of credit} \tag{9c}$$

(9b) and (9c) are the correct specifications for each equation (regime), $\lambda_1$ and $\lambda_2$ are the Inverse Mills Ratios (IMR), $(\rho_1\sigma_1)$ and $(\rho_2\sigma_2)$ are the population regression coefficients relating the $\varepsilon_{1i}$ to $\nu$ and $\varepsilon_{2i}$ to $\nu$, respectively, and $\tau_{1i}$ and $\tau_{2i}$ are errors with zero mean and variance non constant. Thus, in terms of expected value would be

$$E(y_{1i} \mid D = 1) = \delta' x_i + (\rho_1\sigma_1)\, \lambda_{1i} \quad \text{(for the constrained credit or recipients of credit)} \tag{9b'}$$

$$E(y_{2i} \mid D = 0) = \beta' x_i + (\rho_2\sigma_2)\, \lambda_{2i} \quad \text{(for the unconstrained credit or non-recipients of credit)} \tag{9c'}$$

### 3.3.2 Estimation Procedures

Using the sub-samples separately it is possible to consistently estimate the parameters of ecah equation with a two-step method (Lee, 1978; and Heckman, 1979); however, the variance of the parameters estimated should be corrected with the covariance matrix suggested by Lee *et al.* (1980). The two-step method is as follows. To obtain estimates of $\gamma' z$ by a Probit estimation, to get estimated values of $\phi(\gamma' z_i)$ and $\Phi(\gamma' z_i)$, being $\phi$ and $\Phi$ the standard normal density and cumulative density functions, respectively. From those results, we estimate each IMR ($\lambda_1$ and $\lambda_2$), and with those auxiliary variables consistently estimate the parameters with OLS regressions using the appropriate sub-samples. Note that according to the model structure, we can only get estimations for $(\rho_1\sigma_1)$ and $(\rho_2\sigma_2)$ but not for $\rho$ and $\sigma$ separately. Although this procedure is simple, several papers criticize the technique because there is a high potential collinearity between the Inverse Mills Ratio and the regressors, when $z$ is quite similar to $x$ (Nelson, 1984; Nawata, 1994; and Puhani, 2000).

On the other hand, it is possible to estimate *more efficiently* the parameters of this system using maximum likelihood methods, so we have the following likelihood function

$$L(\delta,\beta,\sigma_1,\sigma_2,\sigma_{1v},\sigma_{2v}) = \prod \left[ \int_{-\infty}^{\gamma' z_i} g(y-\delta' x_i, \varepsilon_{1i}) d\varepsilon_{1i} \right]^{D_i} \left[ \int_{-\gamma' z_i}^{\infty} f(y-\beta' x_i, \varepsilon_{2i}) d\varepsilon_{2i} \right]^{1-D_i} \quad (10)$$

where $g$ and $f$ are the bivariate normal density functions of ($\varepsilon_{1i}$, ν) and ($\varepsilon_{2i}$, ν), respectively. All the parameters (Probit and ***y*** for each regime) are estimated jointly by Maximum Likelihood (ML) using two-step method estimates as starting values. Given the structure of the ML equation, separate estimates for $\rho_1$ and $\sigma_1$, and then $\rho_2$ and $\sigma_2$ are possible.

Unfortunately those procedures (Two-step and FIML) are unable to measure *from a statistical point of view* if there are differences between the parameters of each regime, which is fundamental to justify its use and to measure the impact. However, it is possible to estimate both equations (regimes) using all the observations at the same time[13]. Note that

$$E(y_i) = E(y_{1i} \mid D = 1) \text{ Prob } (D = 1) + E(y_{2i} \mid D = 0) \text{ Prob } (D = 0)$$

and if each equation has the same independent variables, $x$, we have

$$E(y_i) = \beta' x_i + (\delta - \beta) [x_i \Phi(\gamma' z_i)] + (\rho_1 - \rho_2) \phi(\gamma' z_i)$$

$$E(y_i) = \beta' x_i + \alpha [x_i \Phi(\gamma' z_i)] + \omega \phi(\gamma' z_i) \quad (11)$$

Note that if the regime 1 has one additional independent variable, for example $s_i$, then the expected value is

$$E(y_i) = \beta' x_i + \eta [s_i \Phi(\gamma' z_i)] + \alpha [x_i \Phi(\gamma' z_i)] + \omega \phi(\gamma' z_i) \quad (12)$$

where $\alpha = \delta - \beta$, $\omega = \rho_1 - \rho_2$, and η is the direct effect of the variable $s_i$. Thus, estimating this regression with OLS allows for testing which coefficients are different between regime 1 and regime 2, which is fundamental to measure the impact of the different status. This is a

13 Even in this case, the model continues being Heterocesdastic, and it is necessary to estimate it with robust standard errors (White, 1980).

convenient procedure for imposing cross-equation restrictions in switching regression models with endogenous switching (Madalla, 1983, pages 227-228)[14].

### 3.3.3 Testing normality

Given that the joint normality assumption plays a key role in the estimation of an endogenous switching regression model, we checked the normality using the approach suggested by Pagan and Vella (1989). They suggest a simple test equivalent to the Regression Specification Error Test (RESET) by testing if the variables added to the second-stage estimator in the two-step estimation procedure are jointly zero. Those variables are defined as

$$(\gamma_i ' z_j)^t \times W \quad (t = 1, 2, 3), \qquad (13)$$

$$\boldsymbol{W} = \begin{cases} \dfrac{\phi(\gamma_i ' z_i)}{\Phi(\gamma_i ' z_i)} & \text{for constrained credit or recipient of credit} \\ \\ \dfrac{\phi(\gamma_i ' z_i)}{(1-\Phi(\gamma_i ' z_i)} & \text{otherwise} \end{cases}$$

### 3.3.4 Treatment Effect

The formulations developed in the previous section permit us to measure the impact (treatment effect) by comparing the ***y*** of the individuals who belong to regime 1, [E( $y_{1i}$ | D = 1)], with their *counterfactual expectation*. This measures the expected potential outcome that the individuals of the regime 1 would have had if they had belonged to regime 2, [E( $y_{2i}$ | D = 1)]. According to Maddala (1983, pages 261-262), under the normality assumption, the expected impact of belonging to group D = 1 would be

$$E(y_{1i} \mid D = 1) - E(y_{2i} \mid D = 1) = (\delta - \beta)\,\overline{x_i} + (\rho_1 - \rho_2)\left[\frac{\phi(\gamma' z)}{\Phi(\gamma' z)}\right] \qquad (14)$$

[14] An example is found in Lee *et al.* (1979), who follow this approach to apply tests for equality of coefficients across regimes in switching simultaneous equation systems with selectivity.

This result is attractive because we can estimate the impact using the parameters already estimated taking the average of $x_i$ and $\phi/\Phi$ for the sub-sample D = 1. Thus, the first part in the right side measures the average effect assuming that the individual is selected at random from the overall population. The second term measures the impact explained by unobserved individual characteristics intervening in the systematic selection or conditioning on the basis of the unobserved individual characteristics. Note that under self-selection, for example, those individuals who have a comparative advantage of getting credit will take advantage of it, and therefore will benefit more from it than would a randomly selected individual with the same characteristics.

### 3.3.5 Empirical applications

The SRM have been widely used in different fields such as labor economics, marketing, migration analysis, financial markets, real state markets and the agricultural sector. The works in the agricultural sector have dealt with adoption (Simtowe and Zeller, 2006), investment (Foltz, 2004 and Carter and Olindo, 2003), land market (Carter and Olindo, 1998; and Vance and Geoghegan, 2004), efficiency (Rahman, 2002; Sriboonchitta and Wiboonpongse, 2004; and Solis *et al.,* 2007), and agricultural production. The production analysis has been focused on two lines of research: credit market in equilibrium and in disequilibrium. The equilibrium analysis has dealt with the impact of credit programs on production from the treatment effect literature (Carter, 1989 and Sial and Carter, 1996), and the effect of technological adoption decisions on production (Fuglie and Bosch, 1995; Tauer, 2003; and Arega and Manyong, 2007). All papers separately estimate two equations, adjusting each one by the selection bias.

The disequilibrium analysis has studied the effect of credit constraint on production where credit may be constrained because of unresolved problems of adverse selection or moral hazard in the credit markets (Stiglitz and Weiss, 1981). Feder *et al*. (1990) was the first work from which more papers have emerged in this line.

**Table 6** summarizes those works; we reviewed the dependent variable used, the estimation method used, whether the impact was measured, whether both normality and the statistical differences among the parameters were estimated, and, in the case of the studies of credit constraint, we presented information about how they tested the hypothesis of Liquidity (HL).

From **Table 6**, we can say that in most of the studies, the amount of physical output has been used as a dependent variable, and the predominant estimation method has been the two-stage procedure (Heckman's procedure); however, some of these studies have only used Weighted Least Squares (WLS) and not the procedure suggested by Lee *et al.* (1980) to correct the covariance matrix. On the other hand, Full Information Maximum Likelihood (FIML) has been used in only two applications. Additionally, no study checked normality, which is a key assumption in the selection models, and few studies checked the statistical differences among the parameters, which is the base justification to estimate equations in different regimes.

**Table 6**
**Studies related to production using switching regression models**

| Studies | Dependent variable | Method used | Measuring impact | Testing | | |
|---|---|---|---|---|---|---|
| | | | | Normality | Differences in parameters | hypothesis of Liquidity / Based on Micro Foundations |
| **Credit Market in Disequilibrium** | | | | | | |
| ***Credit Constraint*** | | | | | | |
| Feder *et al.* (1990) | O | Two-Step | No | No | No | Yes/Yes |
| Freeman *et al.* (1998) | O | Two-Step | No | No | No | No |
| Duong and Izumida (2002) | V | Two-Step | No | No | No | Yes/No |
| Foltz J. (2004) | PP | Two-Step | No | No | No | Yes/No |
| Nelson and Temu (2005) | O | Two-Step | No | No | No | Yes(*)/No |
| **Credit Market in Equilibrium** | | | | | | |
| ***Credit*** | | | | | | |
| Carter M. (1989) | PP and O | OLS | Yes | No | Yes | |
| Sial and Carter (1996) | V | OLS | Yes | No | Yes | |
| ***Adoption*** | | | | | | |
| Fuglie and Bosch (1995) | O and RN | Two-Step | Yes | No | No | |
| Tauer L. (2003) | O and NFI | FIML | Yes | No | No | |
| Arega and Manyong (2007) | O | FIML | No | No | No | |
| ***Efficiency*** | | | | | | |
| Rahman S. (2002) | P | Two-Step | No | No | No | |
| Sriboonchitta and Wiboonpongse. (2004) | O | Two-Step | No | No | No | |
| Solís *et al.* (2007) | V | Two-Step | No | No | No | |

O = Output, V = Value of the production, NFI = Net farm income, P = Profits (income minus costs), PP = Pseudo-Profit (Market value of production less intermediate input and hired labor costs), and RN = Net return (Income minus Chemical input costs)

(*) The study used the chemical input expenditure as an independent variable, which is wrong if it is considered a variable input.

Source: Own review

Concerning the credit constraint studies, most of them tested the hypothesis of liquidity (HL) following Feder et al. (1990); however, this study was the only one that supported their results based on micro-economics foundations. Freeman et al. (1998) and Nelson and Temu (2005) did not check the hypothesis of liquidity because they used variable inputs in the estimations, which would be wrong if those inputs depended on liquidity in the short-term. Moreover, the studies did not measure the impact on the average production associated with each regime, from a *treatment effect* literature point of view, with the exception of Carter (1989), and Carter and Sial (1996), who measured the impact of credit. Finally, in the papers reviewed, there is not a discussion about the modeling of technology, and in several cases a Cobb Douglas representation is simply assumed.

### 3.3.6 Link between Switching Regression Model (SRM) and Stochastic Frontier Analysis (SFA)

In another line of research, some studies have researched the impact of technological adoption decisions on production by combining the literature of efficiency analysis and switching regression models (Rahman, 2002; Sriboonchitta and Wiboonpongse, 2004; and Solís *et al.*, 2007). Those studies indirectly analyze the effect on production by distinguishing from the total errors one part of them that would be associated with inefficiency. They use the standard techniques to measure efficiency with the exception that the production functions of each regime are adjusted by the Inverse Mill Ratio (IMR), which is an auxiliary variable that captures the potential selection bias associated with the nonrandom nature of the sample, in order to consistently estimate the parameters of the production function. In this case, the correction is conducted to improve the estimation of the underlying technology and so to improve the estimated inefficiency. On the other hand, it is possible to correct the potential selection bias related to self-selectivity by directly incorporating the auxiliary variable (IMR) in the inefficiency model instead of the production function such as Zavale *et al.*, (2005). In this case the idea is to improve the estimations of the variables that explain inefficiency given a ranking determined by the estimation of the production function. At this point, a question appears; what is more suitable to estimate the efficiency level or the ranking as precisely as possible?. In Chapter VII, we indirectly deal with this question.

However, a central point in this analysis is to properly correct the standard errors due to the two-step nature of the estimation procedure, not only at the production function parameter level, but also regarding the parameters behind the inefficiency model. However, the works cited in Table 6 have not tested whether there are differences in the parameters in both the production function and in the inefficiency model. Additionally, they have not tested normality, and evaluations of impact have not been conducted.

Notice that these types of models need to make at least two assumptions in terms of distributions, which in some cases could be very restrictive in empirical applications: one for selection process and another for inefficiency term. On the other hand, from my point of view, the advantages of modeling in this way are not clear, in comparison to directly incorporate the variable of switching as a dummy variable in the inefficiency model, and then, if there is evidence for endogeneity, it is possible to use instrumental variables to improve the estimations. This procedure is used in Chapter VI.

# Chapter IV

# Data and variables

## 4.1 Source of information

In 2004 INDAP (Agricultural Development Institute) collected a great deal of information regarding the characteristics of small farmers. The data collected is based on a representative sample with a sampling error of 5%, accounting for the different productive realities around the country. Effectively, in order to have a representative sample of the national situation, the data was collected taking into account the different agro-climate conditions of the country.

To do that, the sample was stratified into six macro zones (Figure 3, Chapter II) and 2,024 surveys were carried out. However, a non-statistical criterion was used in macro zones 1 and 6 due to the large expanse of the territory and the low presence of farmers there. Given our interest in doing a statistical inference of the results, we focus on macro zones 2, 3, 4 and 5, which account for 97% of total small farmers and more than 90% of their production structure (last row in Table 3, Chapter II) with 1,931 surveys. The questionnaire involved several questions concerning the activities of crops, livestock, horticulture and fruit (**Appendix 1**).

## 4.2 Collected variables

The variables directly collected in the interview are summarized in **Table 7**

**Table 7**
**Variables collected in interview**

| | |
|---|---|
| Y [(1)] | On-farm income (thousands of pesos) |
| TI [(2)] | Total income (thousands of pesos) |
| Y/FS | On-farm income per capita (thousands of pesos) |
| Y/A | On-farm income per hectare (thousands of pesos) |
| OTHERINP | Subsidies from Government plus pensions per person (thousands of pesos) |
| A | Used land (hectares) |
| AV | Market value of livestock evaluated at average prices of the sample (thousands of pesos) |
| WC | Working capital (thousands of pesos) |
| OA | Quantity of own land (hectares) |
| POA | Proportion of own land |
| PIA | Proportion of irrigated land |
| DL3 | 1 if household is located in macro zone 3 |
| DL4 | 1 if household is located in macro zone 4 |

| | |
|---|---|
| DL5 | 1 if household is located in macro zone 5 |
| DGL | 1 if farmer has spent some money on animal health during the year |
| EDU | Years of schooling of the head of family |
| AGE | Age of the head of family |
| DSEX | 1 if the head of family is male |
| SHA | Share of the on-farm income over total income |
| DEX | 1 if the farmer had extension services (financed either privately or publicly) |
| ACC | Kms. to get to the main road |
| FS | Family size |
| CS (3) | Credit scoring |
| DOPR | 1 if some household member belongs to an organization |
| INDEX (4) | Value of the Herfindahl index |
| DEPOLDP | Ratio of older people (>65 years old) to family size |
| DEPCHILD | Ratio of children (<15 years old) to family size |
| DEPEND | Ratio of children plus older people to family size |
| NDEPEND | Number of dependents (children and old people) |
| MFS | Ratio number of males to family size |
| TST | Total household's years of schooling |
| DMANAG (5) | 1 if farmer spends some money on management during the year |
| DCC | 1 if household is constrained |
| DOFF | 1 if some household member participates in off-farm activities |
| INC2000 (6) | Perception of on-farm income with respect to situation in 2000 |
| CRED (7) | Amount of credit received (millions of pesos) |
| DCRED | 1 if household receives credit |
| DINDCRED | 1 if household has received credit from INDAP during recent years |
| DINDAP | 1 if household receives some support from INDAP |
| DINDTYPE | Historical payment behavior of INDAP's clients, taking values 1, 2 and 3 (the worst one) |

**Notes:**

(1) The on-farm incomes for each activity (crop, livestock, fruit and vegetables) were built using the market prices as weight for each product.

(2) Total income = on-farm income + off-farm income + other incomes (subsidies from the government + pensions)

(3) The variable credit scoring ranks the lender perception regarding the borrower based on the cleanliness and order of his house and farm. Several items are evaluated by assigning values from 1 to 4 to each one (being 4 the worst evaluation). Thus, an indicator is built by estimating the mean value of all items, and the final score is between 1 and 4.

(4) The Herfindahl index measures the grade of specialization in the on-farm production. This is estimated for observation *i* (farm) and is defined as the sum of the revenue share squared of each activity developed on the farm. Thus, if the farm is fully specialized, the index will be equal to 1.

(5) In the interview, several questions were asked concerning the behavior of farmers in relation to their efforts to improve their management. Thus, if a farmer spent some money during the past year on some item that was consulted, then the dummy variable takes the value

of 1; otherwise it is 0. For example, some of the questions were: Have you or somebody in the household attended a training course paid for by yourself? Have you paid for accounting services? Do you have a contract with the agro industry? Have you spent any money to improve your soils?

(6) This variable measures the farmer perception with regard to the trend of the profitability of the on-farm incomes. Thus, farmer reveals his expectation about how good the business has been during the last years, in particular regarding 2000. This is a categorical variable that takes the values of 1, 2, 3, 4, and 5, with 5 being the worst evaluation of business (on-farm incomes).

(7) The variable credit only considers formal credit, which comes from either public or private institutions. This variable does not take into account the informal sources such as agro-industry, friends, and relatives.

### 4.3 Estimated family labor force

According to the information gathered, the small farmers do not have hired labor so we estimated a weekly family labor force. We estimated the number of daily hours spent in on-farm activities for each person in the household and then multiplied this by 6 in order to have a weekly estimation (TA). The assumptions made in the estimations are summarized in **Table 8.**

**Table 8**
**Assumptions made in the estimation of the on-farm working day (TA)**

| Sex | Age | Main Activity | Working day (hours) | % of Working day | Income share (IS) | On Farm working day |
|---|---|---|---|---|---|---|
| Male | >=15 y <= 80 | Agricultural with other activities own no agricultural | 8 | | IS | 8*IS |
| | | Housework with other activities no agricultural | 8 | 50% | IS | 8*0.5*IS |
| | | Off farm employment | 8 | | IS | 8*IS |
| | | Other activities own no agricultural | 8 | | IS | 8*IS |
| | | Agricultural | 8 | | | 8 |
| | | Student | 8 | 20% | | 8*0.2 |
| | | Housework | 8 | 50% | | 8*0.5 |
| | | Unemployed | 8 | | | 8 |
| | | Retired | 8 | | | 8 |
| Female | >=15 y <= 65 | Agricultural with other activities own no agricultural | 8 | | IS | 8*IS |
| | | Housework with other activities no agricultural | 8 | 50% | IS | 8*0.5*IS |
| | | Off farm employment | 8 | | IS | 8*IS |
| | | Other activities own no agricultural | 8 | | IS | 8*IS |
| | | Agricultural | 8 | | | 8 |
| | | Student | 8 | 20% | | 8*0.2 |
| | | Housework | 8 | 50% | | 8*0.5 |
| | | Unemployed | 8 | | | 8 |
| | | Retired | 8 | | | 8 |

Source: Own definition

However, to have alternative estimations of the family labor force, we changed some assumptions such as age limit for working, time spent by children in on-farm activities and number of hours spent in off-farm activities. **Table 9** shows the alternative assumptions used for estimating the family labor force.

**Table 9**
**Alternative estimations of family labor force**

| Sex | Age | Main Activity | Working day (hours) | % of Working day | Income share (IS) | On Farm working day |
|---|---|---|---|---|---|---|
| | | TB | | | | |
| Male | >=15 y <= 80 | Agricultural with other activities own no agricultural | 8 | | IS | 8*IS |
| | | Housework with other activities no agricultural | 8 | 50% | IS | 8*0.5*IS |
| | | Off farm employment | 8 | | IS | 8*IS |
| | | Other activities own no agricultural | 8 | | IS | 8*IS |
| | | Agricultural | 8 | | | 8 |
| | | Student | 8 | 20% | | 8*0.2 |
| | | Housework | 8 | 50% | | 8*0.5 |
| | | Unemployed | 8 | | | 8 |
| | | Retired | 8 | | | 8 |
| Female | >=15 y <= 65 | Agricultural with other activities own no agricultural | 8 | | IS | 8*IS |
| | | Housework with other activities no agricultural | 4 | 50% | IS | 4*0.5*IS |
| | | Off farm employment | 4 | | IS | 4*IS |
| | | Other activities own no agricultural | 4 | | IS | 4*IS |
| | | Agricultural | 8 | | | 8 |
| | | Student | 8 | 0% | | 8*0 |
| | | Housework | 8 | 50% | | 8*0.5 |
| | | Unemployed | 4 | | | 4 |
| | | Retired | 4 | | | 4 |
| | | TC | | | | |
| Male | >=15 y <= 80 | Agricultural with other activities own no agricultural | 8 | | IS | 8*IS |
| | | Housework with other activities no agricultural | 8 | 50% | IS | 8*0.5*IS |
| | | Off farm employment | 8 | | IS | 8*IS |
| | | Other activities own no agricultural | 8 | | IS | 8*IS |
| | | Agricultural | 8 | | | 8 |
| | | Student | 8 | 20% | | 8*0.2 |
| | | Housework | 8 | 50% | | 8*0.5 |
| | | Unemployed | 8 | | | 8 |
| | | Retired | 8 | | | 8 |
| Female | >=15 y <= 60 | Agricultural with other activities own no agricultural | 8 | | IS | 8*IS |
| | | Housework with other activities no agricultural | 8 | 50% | IS | 8*0.5*IS |
| | | Off farm employment | 8 | | IS | 8*IS |
| | | Other activities own no agricultural | 8 | | IS | 8*IS |
| | | Agricultural | 8 | | | 8 |
| | | Student | 8 | 20% | | 8*0.2 |
| | | Housework | 8 | 50% | | 8*0.5 |
| | | Unemployed | 8 | | | 8 |
| | | Retired | 8 | | | 8 |
| | | TD | | | | |
| Male | >=15 y <= 80 | Agricultural with other activities own no agricultural | 8 | | IS | 8*IS |
| | | Housework with other activities no agricultural | 8 | 50% | IS | 8*0.5*IS |
| | | Off farm employment | 8 | | IS | 8*IS |
| | | Other activities own no agricultural | 8 | | IS | 8*IS |
| | | Agricultural | 8 | | | 8 |
| | | Student | 8 | 20% | | 8*0.2 |
| | | Housework | 8 | 50% | | 8*0.5 |
| | | Unemployed | 8 | | | 8 |
| | | Retired | 8 | | | 8 |
| Female | >=15 y <= 65 | Agricultural with other activities own no agricultural | 8 | | IS | 8*IS |
| | | Housework with other activities no agricultural | 4 | 50% | IS | 4*0.5*IS |
| | | Off farm employment | 4 | | IS | 4*IS |
| | | Other activities own no agricultural | 4 | | IS | 4*IS |
| | | Agricultural | 8 | | | 8 |
| | | Student | 8 | 20% | | 8*0.2 |
| | | Housework | 8 | 50% | | 8*0.5 |
| | | Unemployed | 4 | | | 4 |
| | | Retired | 4 | | | 4 |

Source: Own definition

## 4.4 Study unit

The study unit is a farmer with land, a minimum on-farm income of 185 dollars per year that accounts for at least one percent of total income, a positive working capital larger than or equal to the total production cost when it was available, and a positive estimated labor force. Additionally, because the main production activities in the country, at the small farmer level, are crop and livestock, we avoid fruit-oriented and vegetable-oriented farmers. In doing so, we imposed the constraint that the sum of the on-farm income share of fruit and vegetables should not be larger than 25%. Thus, we ensure that any farmer is biased in those activities, and the farmers could be crop-oriented, livestock-oriented or without any orientation (diversified producers).

## 4.5 Data base

The study area has 1,094 farmers who were carefully checked, dropping the variables that showed inconsistencies. **Table 10** shows the lost observations for type of inconsistency. For example, although some farmers answered that they produce crops, they did not provide information about production or income from this activity or they showed inconsistencies in the amount of used land. Additionally, the inconsistencies in livestock production are associated with farmers that reported incomes in livestock production but they did not report about livestock and/or availability of land, and farmers that reported a large number of animals but they did not report their income. Finally, the financial inconsistencies are related to levels of profitability over what is expected. According to the sectorial expert opinions, the profitability in small farmers, measured as the ratio of the difference of on-farm income and working capital to working capital, should not be larger than 4.5 times, even taking into account the availability of inventories.

**Table 10**
**Checked data for inconsistencies**

| | Observations | Lost Observations |
|---|---|---|
| **Total Original Sample** | **1,094** | |
| Inconsistencies in crop, greenhouse and fruit activities | 1,030 | 64 |
| Inconsistencies in livestock activity | 934 | 96 |
| Inconsistencies in Land | 898 | 36 |
| Inconsistency based on financial criterion | 835 | 63 |
| **Total Final Sample** | **835** | |
| **Total lost observations** | | **259** |

Source: Own calculations using survey data

Thus, the final sample is composed of 835 farmers, which maintains the distribution at the macro zone level (**Table 11**).

**Table 11**

**Final Data**

| Macro Zone | Study sample | | Final study sample | |
|---|---|---|---|---|
| | Number | % | Number | % |
| **2** | 166 | 15% | 114 | 14% |
| **3** | 296 | 27% | 201 | 24% |
| **4** | 281 | 26% | 224 | 27% |
| **5** | 351 | 32% | 296 | 35% |
| **Total** | 1,094 | 100% | 835 | 100% |

Source: Own calculations using survey data

## 4.6 Groups of farmers

The final sample was divided into three sub-groups depending on the grade of orientation in the production, and dummy variables were used to represent those groups. DLIVE takes the value 1 if the livestock on-farm income share is equal to or larger than 70%[15], DCROP takes the value 1 if the crop on-farm income share is equal to or larger than 70%, and DMIX takes the value 1 if there is not any sector with an on-farm income share greater than 70%. In other words, DMIX measures farmers that are not specialized at all. **Table 12** shows that there are 457 crop producers, 213 livestock producers and 165 mixed producers, which account for 55%, 26%, and 20% of the total sample, respectively.

**Table 12**

**Final data grouped in sub-samples**

| Sector | Specialization | Number | % |
|---|---|---|---|
| Crop | H = 1 | 342 | 41% |
| | H < 1 | 115 | 14% |
| ***Total Crop*** | | ***457*** | ***55%*** |
| Livestock | H = 1 | 109 | 13% |
| | H < 1 | 104 | 12% |
| ***Total Livestock*** | | ***213*** | ***26%*** |
| | | | |
| ***Mix*** | H < 1 | ***165*** | ***20%*** |
| **Total** | | **835** | **100%** |

H = Herfindahl index

Source: Own calculations using survey data

15 The literature reviewed uses values between 50% and 75% (Manthijs *et al.* (1999), Manthijs and Vranke (2000), Brummer and Loy (2000), Kopeva and Noev (2002) and Latruffe *et al.* (2005)).

The original sample of specialized producers (H = 1) is 142 farmers in livestock and 470 farmers in crop. After cleaning this data, the sample is composed of 342 crop-specialized and 109 livestock-specialized producers. On the other hand, the original sample of non-specialized farmers (H <1) is 442 farmers and after checking their consistency this group was composed of 384 farmers. In both cases, the distribution at the macro zone level was maintained **(Tables 13 and 14).**

**Table 13**
**Data of specialized producers by macro zone**

| | Livestock | | Final Livestock | |
|---|---|---|---|---|
| **Macro Zone** | **Number** | **Share** | **Number** | **Share** |
| 2 | 20 | 14% | 13 | 12% |
| 3 | 14 | 10% | 8 | 7% |
| 4 | 40 | 28% | 26 | 24% |
| 5 | 68 | 48% | 62 | 57% |
| **Total** | **142** | **100%** | **109** | **100%** |

| | Crop | | Final Crop | |
|---|---|---|---|---|
| **Macro Zone** | **Number** | **Share** | **Number** | **Share** |
| 2 | 117 | 25% | 82 | 24% |
| 3 | 209 | 44% | 164 | 48% |
| 4 | 91 | 19% | 65 | 19% |
| 5 | 53 | 11% | 31 | 9% |
| **Total** | **470** | **100%** | **342** | **100%** |

Source: Own calculations using survey data

**Table 14**
**Data of non-specialized producers by macro zone**

| **Macro Zone** | **Non-specialized** | | **Final non-specialized** | |
|---|---|---|---|---|
| | **Number** | **Shara** | **Number** | **Shara** |
| **2** | 29 | 7% | 19 | 5% |
| **3** | 39 | 9% | 29 | 8% |
| **4** | 147 | 33% | 133 | 35% |
| **5** | 227 | 51% | 203 | 53% |
| **Total** | **442** | **100%** | **384** | **100%** |

Source: Own calculations using survey data

# Chapter V

# Financial Markets and the Determinants of Technical Inefficiency among Specialized Small Farmers

## 5.1 Introduction

Chile is a country with a privileged geographic location, great climate variety, and riches in renewable natural resources; thus, Chilean agriculture has become one of the main productive activities showing a very interesting growth dynamic during the last three decades. There have been various explanations for this, but there is no doubt that Chile's trade-opening process and its sectorial public policy help to explain the current achievements.

As a result of the opening process, tariffs have systematically dropped in the last years; however, at the aggregate level, agricultural producers have maintained their production levels or even in some cases have increased them. However, in this context of success, the levels of efficiency of the agricultural sector have not been studied at all, either at the processing (agro industry) level or at the productive (providers) level. Understanding what happens with the levels of efficiency and what forces are behind them are key issues to public policy today and in the future.

At the production level, it is possible to distinguish three kinds of agricultural producers in Chile–small, medium and large–each one having different challenges and realities. According to official information, there are more than 278,000 small farmers with an average of 14 hectares in Chile, accounting for 85% of total farmers. However, this small agriculture is characterized by a high heterogeneity in the production, technology and access to financial markets.

The future of the smallholders is not only based on access and consolidation of markets, but also on technological advances, improvements in management capacity, and access to financial markets. The last is a complex topic because the banks perceive the cash flow of small farmers as low and uncertain, making it harder for farmers to get credit and in this way affecting their levels of efficiency.

The measurement of technical efficiency in the agricultural sector of developing and developed countries has received much attention in recent years. There have been a vast number of applications of frontier methodologies in empirical studies at the farm-level data in a large number of countries. They have used both parametric and non-parametric approaches, in which the former allows observations to depart from the frontier due to random error and/or inefficiency, and the latter measures random error as part of inefficiency; that is, they confuse random error with inefficiency (any departure from the frontier is measured as inefficiency).

We use a parametric approach for two important reasons: First, there is the possibility of collecting agricultural data measured with errors and the presence of random errors because of natural conditions (for example, weather, disease and pest infestation). Second, we are interested in understanding the technology behind the production decisions and making inference regarding the estimates.

Apparently, the new situation in the country's agricultural economy provides opportunities for livestock production but threatens crop production. Using a wide sample of small farmers collected in 2004, we studied two groups of specialized producers, crop and livestock. We selected those sectors because they are basically composed of small farmers and have different perspectives of development. Moreover, we focused on specialized producers because it is easier to model their technology.

The study aims at measuring the relative technical efficiency of small farmers and attempts to identify the main factors behind the inefficiency observed. In particular, this work will focus on the importance of the credit market to explain the scores of inefficiency. Additionally, we take into account the potential simultaneity of the financial variables with technical efficiency.

An attempt will be made to answer the following questions: What are the technological parameters of the specialized small farmers? Are there significant inefficiencies in these small farmers and are these inefficiencies basically explained by access to the credit market? Are the scores of efficiency measured with accuracy? Have the efforts of public policy contributed to increase the levels of efficiency of small farmers?

From an empirical point of view, this study provides three contributions. First, it will be the first one in Chile that deals with estimations of technical efficiency and technological parameters of small farmers by using a country-wide sample. We are aware of just two previous studies of efficiency in the Chilean agricultural sector. Santos *et al.* (2006) studied technical efficiency in potato production in the country's central zone and Moreira *et al.* (2006) studied the technical efficiency and technological change for a sample of small dairy farmers in the southern zone.

Second, we model, at the small farmer level, the variance of the inefficiency term instead of its mean. A few studies have followed this method and they are basically focused on agriculture of a larger size. Thus, this research contributes by analyzing small farmers and incorporating a wide range of variables to explain the variance of the inefficiency term.

Third, this chapter analyzes the impact of some financial variables on technical inefficiency by explicitly considering problems related to their potential simultaneity with the inefficiency and we try to assert a different point of view concerning the impact and extent of credit constraint on smallholders. In empirical applications, credit constraint analysis has focused on its causes, determinants and indirect impacts on some variables of interest such as production and adoption.

## 5.2 Model specification and data analysis

### 5.2.1 Model specification[16]

We built on-farm incomes for each activity (crop, livestock, fruit and vegetables) using the market prices as weight for each product. Thus, we used the value of total output generated as the dependent variable[17]. Based on that, we built the Herfindahl index to identify the grade of specialization of each farmer and selected those farmers with an index equals to one. Thus, we

[16] See Chapter IV for details about variables and data.

[17] This practice has widely been used in the literature, but it is important to keep in mind that the efficiency estimated is more precisely a measurement of economic efficiency because we are using the value of total output (Coelli and Battese, 1996). Given the geographical dispersion of our sample, we considered an adjusted measurement of the prices by taking into account the transport costs of moving the products from each zone to Santiago, the capital of Chile; however, our results did not change, probably because we are already taking into account localization with dummy variables. Finally, the efficiency estimated would be incorporating the skill of farmers in selling their products, which is clearly very important, in particular for the case of small farmers.

identified 342 specialized crop producers and 109 specialized livestock producers.

We define the following translog production function

$$\log y = \beta_0 + \sum_{i=1}^{4} \beta_i \log x_i + \frac{1}{2}\sum_{i=1}^{4}\sum_{j=1}^{4} \beta_{ij} \log x_i \log x_j + \gamma_1 PIA + \gamma_2 \frac{(PIA)^2}{2} + \sum_{k=1}^{4} \omega_k (PIA) \log x_k + \sum_{d=1}^{4} \eta_d D_d + \nu - \mu$$

where β, γ, ω and η are unknown parameters, $\boldsymbol{v}$ is a pure random term (white noise), *u* is a systematic, nonnegative error term accounting for efficiency, log y is the decimal logarithm of on-farm total income and log x is the decimal logarithm of four inputs; used land (A), working capital (WC) as a proxy of intermediate inputs, the market value of livestock evaluated at the average prices of the sample (AV) as a proxy of capital stock, and estimated family labor force (TA). In addition, we use two additional variables to take into account differences in the quality of soil and localization of the farms[18]. The proportion of irrigated land (PIA) is used as proxy of quality of soil and the dummy variables (DL) measure differences in localization. Thus, DL3, DL4, and DL5 are equal to 1 if a farmer is located in macro zone 3, 4 or 5, respectively, using as reference the macro zone 2. Some farmers in crop production do not have animals so an additional dummy variable (DAV) is used to correct the potential bias of the parameters estimated (Battese G, 1997), where Dav is equal to1 if AV is greater than 0.

The elasticities of the production factors, *x*, and the proportion of irrigated land (PIA)[19] are expected to be positive for obvious reasons. The location dummies (DL3, DL4 and DL5) will

18 Sherlund *et al.* (2002) show the necessity of considering the control variables when the inefficiency is modeled otherwise biased estimates can be obtained.

19 According to Battese *et al.* (1989) the parameter of the variable proportion of irrigated land (PIA) permits to test if there are differences in productivity between one hectare with irrigation and one without irrigation. They assert that the variable land could be a weighted average of irrigated land and unirrigated land (Land = UL+IL), so the production function would be

$$y = \alpha_0 \left( \alpha_1 UL + \{1 - \alpha_1\} IL \right)^{\beta_1}$$

Thus, the model could be expressed in terms of Land and IL/Land, as follows.

$$y = \alpha_0 \alpha_1^{\beta_1} Land^{\beta_1} \left[ 1 + \{\phi_1 - 1\}\{IL / Land\} \right]^{\beta_1}$$

where ф1=(1-α1)/α1 and ф1 is the value of one hectare of irrigated land in terms of unirrigated land. Taking log both sides and considering only the first term of the infinite series expansions of the function involving the land ratio, IL/Land, we obtain

Log y = Constant + $\beta_1$ Log (Land) +$\beta_2$ (IL/Land), where $\beta_2 = \beta_1(\Phi_1 - 1)$

have positive or negative impacts as geographic zones are better or worse suited to production; for example, moving south from the reference zone 2 into colder and wetter zones, crop production is expected to fall, all other things being equal. The sign of the coefficient on DAV is indeterminate *a priori*.

We assume symmetry ($\beta_{ij} = \beta_{ji}$), and $v$'s are independent and identically distributed (*i.i.d.*) normal random variables with a mean of zero and constant variance ($\sigma_v^2$) independent of the $u$'s. Following Caudill *et al.* (1995) and Brümmer and Loy (2000), systematic deviations from the frontier $u_i$ are assumed to be *i.i.d.* half-normal random disturbances uncorrelated with $v$, with mean zero and a heteroscedastic (i.e., farm-specific) variance $\sigma_{ui}^2$ such that[20]

$$\log(\sigma_{ui}^2) = \log\sigma_0 + \Sigma\phi_j z_j + \xi_i,$$

where $\phi_j$ are parameters to be estimated that measure the influence of variables in z on efficiency, and $\xi_i$ are independent and identically distributed (*i.i.d.*) normal random variables with a mean of zero and constant variance.

The vector $z$ represents factors that influence efficiency which includes six categories of variables.

Three variables account for socioeconomic characteristics of the farm household. These are the age and education of the household head (AGE and EDU, both in years), and the size of the household (FS, family size). Inefficiency is expected to decrease with increasing age (AGE) and education (EDU) of the household head. The size of the household (FS) is expected to have a positive relationship with efficiency for three reasons. First, the family size is associated with the availability of timely labor. Second, a larger family size puts extra pressure on farm income for clothing and food, so farmers will try to be more efficient. Third, a larger family size means that a variety of labor is available (Children, youngsters, adults, and elderly member). This mix of labor enables the rational household head to assign the right job to the right person[21].

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[20] Chapter III, Section 3.2.2

[21] Several papers have dealt with it (e.g., Abdulai and Eberlin, 2001; Audibert, 1997; Bravo-Ureta and Pinheiro, 1997; Coelli *et al.*, 2002; Hazarika and Alwang, 2003; O'Neill and Matthews, 2001; Parikh *et al.*, 1995; and Wang *et al.*, 1996).

One variable (POA, the share of farmed land that is owned by the household) reflects land tenure conditions. The literature reviewed suggests that farmers who mainly own their land utilize better resource management practices and as a result achieve higher technical efficiency. In addition, ownership is expected to positively affect efficiency because households with legal land rights have the option of selling their land, they have increased investment opportunities, and they can use land as collateral for credit[22].

One variable measures access to markets (ACC, the distance in km to the main road). Access to markets provides advantages in marketing and can be expected to increase a farm's awareness of and access to best practice methods, thus reducing inefficiency.

Eight variables capture management decisions. These include, in addition to the four input variables listed above (A, WC, AV and TA), a dummy that equals one if the farmer has spent money on management training (e.g. attending a training course) or services in the course of the year (DMANAG). The dummy DEX equals one if the farmer has extension services financed either privately or publicly[23], another (DGL) equals one of the farmer has spent some money on animal health during the year, and SHA is defined as the share of on-farm income in total income. It is reasonable to expect inefficiency to fall with increasing values of the management variables DMANAG, DGL and DEX, and as the share of on-farm income in total income (SHA) increases, the time and attention dedicated to running the farm operation efficiently can be expected to increases as well, also reducing inefficiency.

DINDAP is a dummy variable that equals one if the farm in question receives support from INDAP. If public assistance is effective, then DINDAP will have a negative impact on inefficiency.

Finally, two variables measure various dimensions of a farm's access to credit. The first is total credit used (CRED) in millions of Pesos, and, the second is a dummy that equals one if the head of the farm households feels credit constrained (DCC). According to Sections 3.1.2 and 3.2.4 in Chapter III, the sign of the relation between credit and technical efficiency and between credit constraint and efficiency is ambiguous. We therefore formulate no *a priori* expectations for the variables CRED and DCC.

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[22] Some papers that have used this type of variable are Chavas *et al.*, 2005; Fletschner and Zepeda, 2002; Karagiannis and Sarris, 2005; Konstantinos *et al.*, 2001; Llewelyn and Williams, 1996; and Wu *et al.*, 2003.

[23] Extension services have been studied in several papers such as Alene and Hassan, 2003; Bravo-Ureta and Pinheiro, 1993; Bravo-Ureta and Evenson, 1994; O'Neill *et al.*, 1999; Obwona, 2006; Seyouma *et al.*, 1998; and Dinar *et al.*, 2007.

### 5.2.2 Data analysis

81% of the specialised livestock producers identified in this manner are located in the southern-central macro-zones 4 and 5, while 72% of the specialised crop producers are located in the north-central zones 2 and 3. Specialised crop production concentrates on four crops (wheat, maize, potatoes and rice) that account for 90% of land use on the corresponding farms. Specialized livestock production encompasses cattle, sheep and goats, but cattle (milk and beef) account for 70% of farm revenue on these farms. On average, specialized crop and livestock producers have irrigation in 66% and 20% of the total surface, respectively. The descriptive statistics of the samples are given in **Tables 15** and **17**.

From a financial point of view, one third of specialized crop producers get credit of short-term, financed by INDAP (75%), Banco Estado (13%) and Department Stores (9%), with an average credit of 1,300 thousands pesos (US$2,400), which accounts for 54% of their working capital. On average, a 41% of the sample faces credit constraint (**Table 16**). In the case of specialized livestock producers, only 27% of them received credit from INDAP (68%), BancoEstado (20%) and BCI Bank (12%), and cattle production was the activity that received more financing. The average amount of credit received was 535,000 thousands pesos (US$1,000), which financed 48% of its working capital, and 43% of the sample faces credit constraint (**Table 18**). It is remarkable that when farmers specialized do not get credit, the informal sector does not finance them, and the own resources become very important.

## Table 15
## Descriptive statistics of specialized crop producers
**(Sample: 342 observations)**

| Variable | minimum | mean | maximum | std.dev |
|---|---|---|---|---|
| ***Production Function*** | | | | |
| Y | 100 | 2,841.6 | 50,400 | 5,932.1 |
| A | 0.05 | 3.39 | 50 | 4.98 |
| WC | 40 | 2,102.6 | 40,000 | 4,586.8 |
| TA | 6.52 | 93.16 | 289.62 | 43.44 |
| AV | 0 | 183.85 | 1,280 | 280.04 |
| DAV | 0 | 0.43 | 1 | 0.49 |
| ***Control Variables*** | | | | |
| DL2 | 0 | 0.23 | 1 | 0.42 |
| DL3 | 0 | 0.47 | 1 | 0.49 |
| DL4 | 0 | 0.19 | 1 | 0.39 |
| DL5 | 0 | 0.09 | 1 | 0.29 |
| PIA | 0 | 0.66 | 1 | 0.45 |
| ***Public Policy*** | | | | |
| DINDAP | 0 | 0.54 | 1 | 0.49 |
| **Credit market** | | | | |
| DCC | 0 | 0.41 | 1 | 0.49 |
| CRED (millions of pesos) | 0 | 0.43 | 24 | 1.70 |
| DCRED | 0 | 0.33 | 1 | 0.47 |
| ***Management*** | | | | |
| DGL | 0 | 0.10 | 1 | 0.30 |
| SHA | 0.02 | 0.59 | 1 | 0.34 |
| DMANAG | 0 | 0.32 | 1 | 0.46 |
| DEX | 0 | 0.15 | 1 | 0.36 |
| ***Access to market*** | | | | |
| ACC | 0 | 1.91 | 48 | 4.37 |
| ***Socioeconomic*** | | | | |
| FS | 1 | 3.98 | 13 | 1.64 |
| AGE | 24 | 51.10 | 84 | 13.62 |
| EDU | 1 | 7.80 | 26 | 5.83 |
| ***Tenure*** | | | | |
| POA | 0 | 0.45 | 1 | 0.46 |
| ***Instruments*** | | | | |
| CS | 1 | 1.25 | 4 | 0.46 |
| DOPR | 0 | 0.06 | 1 | 0.24 |
| OA | 0 | 3.02 | 35 | 5.36 |
| DINDTYPE | 1 | 2.40 | 3 | 0.83 |
| L(Y/A) | 3.17 | 6.22 | 9.55 | 0.99 |

Source: Own calculations using survey data.
See Chapter IV for details about variables and data

## Table 16
## Credit market in specialized crop production

| | Without Credit | With Credit | Total |
|---|---|---|---|
| **Unconstrained** | 135 | 64 | 199 |
| **Constrained** | 93 | 50 | 143 |
| **Total** | 228 | 114 | 342 |

| | | | |
|---|---|---|---|
| **Formal credit (Pesos)** | 0 | 1,294,377 | 431,459 |
| **Credit Scoring** | 1.28 | 1.22 | 1.25 |
| **Financing:** | | | |
| **Formal** | 0.0% | 54.2% | 18.1% |
| **Informal** | 9.8% | 11.2% | 10.2% |
| **Own resources** (1) | 80.8% | 29.7% | 63.7% |
| **Selling of fixed Assets** | 1.4% | 1.4% | 1.4% |
| **Other**(2) | 8.1% | 3.6% | 6.6% |

(1) Includes seeds, savings, rented land, profits from previous season and selling of animals
(2) Any item that is not included in the others, for example, pensions and income from off-farm activities
Source: Own calculations using survey data

## Table 17
## Descriptive statistics of specialized livestock producers
**(Sample: 109 observations)**

| Variable | Minimum | Mean | Maximum | Std.Dev |
|---|---|---|---|---|
| **Production Function** | | | | |
| Y | 100 | 796.88 | 10,600 | 1,364.50 |
| A | 0.75 | 20.16 | 200 | 25.53 |
| WC | 24 | 1,364.90 | 9,500 | 2,104 |
| TA | 2.94 | 82.54 | 200.31 | 40.96 |
| AV | 176 | 2,298.80 | 16,040 | 2,166.20 |
| **Control variables** | | | | |
| DL2 | 0 | 0.12 | 1 | 0.33 |
| DL3 | 0 | 0.06 | 1 | 0.24 |
| DL4 | 0 | 0.23 | 1 | 0.42 |
| DL5 | 0 | 0.56 | 1 | 0.49 |
| PIA | 0 | 0.20 | 1 | 0.37 |
| **Public Policy** | | | | |
| DINDAP | 0 | 0.56 | 1 | 0.49 |
| **Management** | | | | |
| DMANAG | 0 | 0.49 | 1 | 0.49 |
| DEX | 0 | 0.22 | 1 | 0.42 |
| SHA | 0.01 | 0.42 | 1 | 0.32 |
| DGL | 0 | 0.63 | 1 | 0.48 |
| **Credit Market** | | | | |
| DCC | 0 | 0.43 | 1 | 0.49 |
| CRED | 0 | 0.14 | 4 | 0.45 |
| DCRED | 0 | 0.27 | 1 | 0.44 |
| **Access to market** | | | | |
| ACC | 0 | 1.81 | 35 | 5.29 |
| **Socioeconomic** | | | | |
| FS | 1 | 3.47 | 8 | 1.65 |
| AGE | 31 | 53.30 | 86 | 12.57 |
| EDU | 1 | 7.47 | 25 | 4.80 |
| **Tenure** | | | | |
| POA | 0 | 0.66 | 1 | 0.44 |
| **Instruments** | | | | |
| CS | 1 | 1.32 | 4 | 0.64 |
| DOPR | 0 | 0.25 | 1 | 0.43 |
| OA | 0 | 13.64 | 110 | 19.99 |
| DINDTYPE | 1 | 2.01 | 3 | 1.21 |
| L(Y/A) | 1.05 | 3.59 | 6.50 | 1.15 |

Source: Own calculations using survey data
See Chapter IV for details about variables and data

## Table 18
## Credit Market in Specialized Livestock Production

| | Without Credit | With Credit | Total |
|---|---|---|---|
| **Unconstrained** | 48 | 14 | 62 |
| **Constrained** | 31 | 16 | 47 |
| **Total** | 79 | 30 | 109 |

| | | | |
|---|---|---|---|
| **Formal credit (Pesos)** | 0 | 535,467 | 147,376 |
| **Credit Scoring** | 1.37 | 1.22 | 1.33 |
| **Financing:** | | | |
| **Formal** | 0.0% | 48.5% | 13.4% |
| **Informal** | 0.1% | 0.0% | 0.05% |
| **Own resources** (1) | 85.9% | 44.8% | 74.6% |
| **Selling of fixed Assets** | 0.0% | 0.5% | 0.1% |
| **Other** (2) | 14.0% | 6.2% | 11.9% |

(1) Includes seeds, savings, rented land, profits from previous season and selling of animals
(2) Any item that is not included in the others, for example, pensions and income from off-farm activities
Source: Own calculations using survey data

## 5.3 Methodology

### 5.3.1 Estimation procedure

Maximum Likelihood (ML) estimations are performed in Ox 3.40 (Doornik, 2002) by using the package SFAMB (Stochastic Frontier Analysis using ModelBase)[24]. The estimation procedure follows Battese and Coelli (1995) by estimating all the parameters in one step and Likelihood Ratio (LR) tests are conducted to test different hypotheses.

We estimate the translog production function by using a single equation. It is important to keep in mind that a potential problem associated with this procedure is that the parameter estimates may be subject to some simultaneity bias because inputs can hardly be regarded as really exogenous variables. However, given that we have cross-sectional data and use proxies for some inputs, we estimate a single equation[25].

On-farm income and production input variables are divided by their arithmetic means so that parameter estimates can be directly interpreted as production elasticities evaluated at sample means[26]. The variable working capital is assumed to be a variable input, and the regularity conditions of the production function estimated, monotonicity, linearity and quasi-concavity in the variable input, are checked according to the following expressions (**Table 19**).

According to the literature that we consulted, the regularity conditions are rarely fulfilled globally in empirical work; however, if they are met for a sufficient number of the observed data points, it is considered "well-behaved" and interpretable (Berndt and Christensen, 1973). On the other hand, Thijssen (1992), Salvanes and Tjotta (1996) and Sauer *et al.* (2006) have pointed out the importance of checking quasi-concavity in empirical applications.

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24 SFAMB is a package written in Ox for estimating stochastic frontier production functions (Brummer, 2001).

25 If we had information about costs, we could estimate the production function using an equation system, incorporating cost share equations (Berndt and Christensen, 1973).

26 Each variable transformed will be represented with a M. Thus, for instance, the variable working capital LWC would be LWCM, where L means decimal logarithm.

**Table 19**
**Regularity conditions**

| | | |
|---|---|---|
| • | Monotonicity | $e_i = \frac{\partial \ln f(.)}{\partial \ln x_i} = \beta_i + \sum_{j=1}^{n} \beta_{ij} \ln x_j \geq 0$ |
| • | Linearity | |
| | Constant Return to Scale | $\sum^{n} \beta_i = 1$ |
| | Homothetic | $\sum_{i=1}^{n} \beta_{ij} = 0 \quad j=1,..,n$ |
| • | Quasi concavity | $e^2{}_{wc} - e_{wc} + \beta_{wcwc} \leq 0$ |

Source: Thijssen (1992).

### 5.3.2 Dealing with endogeneity

Possible simultaneity between the financial variables and technical efficiency is an important issue; however, as developed in Section 3.2.4, Chapter III, it has been lightly studied. We are interested in checking whether the amount of credit or the condition of constrained is determined by the performance of farmers in the use of their inputs (technical efficiency).

We use the Durbin-Wu-Hausman test (Davidson and MacKinnon, 1993) to check simultaneity. First, we run a regression of the potential endogenous variable on all the exogenous variables and a *set of instruments*. Those instruments should be variables that are highly correlated to the potential endogenous variables but not with the term error of the original inefficiency model. Second, we run the original model by incorporating the residuals of the previous regression and check the significance of its parameter. The null hypothesis is no endogeneity, which means that the parameters of the residuals should not be significant[27]. Thus, if the test is rejected, we ought to use instrumental variables; otherwise, our estimates will be inconsistent. In case of finding evidence of simultaneity, we correct the estimations by using *fitted values* of each model as instruments of the variable of interest.

The instruments used are the same both for the variable credit and for the variable credit constraint. The logarithm of on-farm income per hectare (Ln[Y/A]) is used as a proxy of

[27] Note that even if we can not find evidence of simultaneity, it does not mean that financial variables are exogenous. According to Davidson and MacKinnon (1993), no evidence of simultaneity only means that there is not bias in the parameters caused by simultaneity.

household wealth; the idea behind of this variable is that high levels of household wealth decrease the necessity of borrowing. The quantity of owned land (OA) is used as a proxy of collateral so that a great amount of owned land could be seen by lenders as a signal of guarantee, increasing farmers' chances of getting credit. The dummy variable relationship with productive organization (DOPR) is used as a proxy of social capital, understanding that the social-productive networks contribute to the access to credit.

Additionally, we use two variables that from a lender's point of view can be proxies of the client's potential quality. The variable credit scoring (CS)[28], and the variable DINDTYPE used as a signal of client quality in the future. DINDTYPE measures the historical payment behavior of farmers, taking values 1, 2, and 3 (the worst one). Thus, low values of DINDTYPE would be associated with higher possibilities of getting credit (**Table 20**).

**Table 20**
**Instruments for the variables credit (CRED) and credit constraint (DCC)**

| Variable | Definition | Type | Proxy |
|---|---|---|---|
| Logarithm of on-farm income per hectare | Ln(Y/A) | Continue | Wealth |
| Own land | OA | Continue | Collateral |
| Relationship with productive organization | DOPR | Dummy 1 if farmer belongs to productive organization | Social Capital |
| Credit score | CS | Continue taking values between 1 and 4 (the worst one) | Lender Perception |
| Historical payment behavior of farmers | DINDTYPE | Categorical. 1,2 and 3, where 3 is the worst | Signaling |

Source: Own definition

It is important to keep in mind that the expected effects mentioned in the previous paragraph are the result of getting credit. However, the amount of credit is the result of the *interaction between demand and supply*, so we can not expect that those effects are an absolute truth, at least in some of the variables mentioned, and they can go in the completely opposite direction. This is valid for the condition of credit constraint as well, because it is possible to define this condition as a situation of excess demand in the credit market[29].

[28] This variable is used to measure creditworthiness and ranges from 1 (most) to 4 (least). This variable is calculated as the average of several subjective evaluations (each on a scale of 1 to 4) of the general cleanliness and order of the household's dwelling and farm (see Chapter IV for a more detailed description of the variables used). This admittedly rough method of assessing creditworthiness is similar to methods that the Banco Estado has implemented in recent years in an attempt to reduce the administrative costs of delivering small rural credits.

[29] Several papers that have studied the factors behind the condition of credit constraint by using Probit or Logit models have had difficulties interpreting the parameters in the model because those variables could explain the supply or demand side of the constraint.

## 5.4 Estimations and discussion

### 5.4.1 Specialized Crop Production

Columns 1 and 2 in **Table 21** depict the results of the different estimations carried out. Based on the LR tests in **Table 22**, the best model (Column 2 in Table 21) does not include the variable *animal market value* (LAVM) in the production function and the variable related to land tenure (POA) in the inefficiency model. This result seems plausible because in small agriculture the variable related to capital would not play an important role, in particular when the market value of the animal stock is used as a proxy of capital. In all the estimations performed, the variable land tenure was not significant, confirming the impression that in Chile the ownership is not an issue even at the small farmers' level. Additionally, the Cobb Douglas representation is not appropriate and the technology translog has a better representation of the data. On the other hand, in **Table 23** we showed that the analysis of the regularity conditions suggests that technology is characterized by monotonicity in all the inputs, quasi concavity of working capital is fulfilled in 100% of the cases in the sample. Additionally, the hypothesis of constant return to scale at sample mean was not possible to reject and the technology would not be homothetic.

The parameters estimated of best model (Column 2 in **Table 21**) show that localization is an important factor in explaining differences in the mean of the on-farm incomes and the variable related to irrigation (PIA) makes differences in productivity between land with and without irrigation. Thus, one hectare with irrigation is more than 7 times more productive than one without irrigation[30]. The partial elasticities of land, labor force and working capital, at sample mean level, are significant with values of 0.33, 0.36 and 0.57, respectively. Given the specification used, the elasticity of working capital with irrigation is 0.69, which would be associated with a larger use of inputs in order to optimize its higher productivity[31].

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30 From footnote 19 we have Log y = Constant + $\beta_1$ Log (Land) +$\beta_2$ (IL/Land), where $\beta_2 = \beta_1(\Phi_1 -1)$ and $\phi_1$ is the value of one hectare of irrigated land in terms of unirrigated land. Thus, using the definition of $\beta_2$ we can estimate $\phi_1$ with the parameters estimated in our model. According to our estimations, $\beta_1$ is equivalent to the parameter related to the variable LAM (0.33), and $\beta_2$ is equivalent to the parameter of the variable PIA (2.12). Therefore, one hectare with irrigation is 7.42 [{2.12/0.33}+1] times more productive than one without irrigation.

31 We can define working capital elasticity as

$$e_{wc} = \frac{\partial \ln f(.)}{\partial \ln x_{wc}} = \beta_{wc} + \sum_{j=1}^{n} \beta_{ij} \ln x_j + \omega_{wc} PIA$$

Evaluated at mean sample level, we have

## Table 21
## ML estimations of specialized crop and livestock production

| Variables | Specialized Crop Producers | | | | Specialized Livestock Producers | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | (1) | | (2) | | (3) | | (4) | | (5) | |
| | Full Model | | Best Model | | Full Model | | Best Model | | Best Model Corrected | |
| | Coefficient | t-test | Coefficient | t-test | Coefficient | t-test | Coefficient | t-test | Coefficient | t-test |
| ***Production function*** | | | | | | | | | | |
| Constant | 0.0630 | 0.05 | -0.1068 | -0.65 | 0.5124 | 1.14 | 0.1207 | 1.34 | 0.0272 | 0.28 |
| LAM | 0.3786 | 3.58 | 0.3341 | 2.88 | 0.1476 | 0.99 | | | | |
| LWCM | 0.5526 | 5.94 | 0.5696 | 5.85 | 0.5252 | 6.35 | 0.5152 | 6.61 | 0.4266 | 6.20 |
| LTAM | 0.3354 | 2.45 | 0.3659 | 2.74 | 0.2061 | 0.91 | | | | |
| LAVM | 0.0072 | 0.11 | | | 0.6713 | 2.75 | 0.8487 | 6.74 | 0.9836 | 8.49 |
| DAV | -0.3546 | -0.29 | | | | | | | | |
| 0.5 LAM^2 | -0.1024 | -1.87 | -0.0950 | -1.39 | 0.0454 | 0.54 | | | | |
| 0.5 LWCM^2 | -0.0268 | -0.59 | -0.0377 | -0.76 | 0.0667 | 1.31 | 0.0863 | 1.87 | 0.0333 | 0.71 |
| 0.5 LTAM^2 | -0.1616 | -1.64 | -0.1042 | -0.94 | 0.0250 | 0.16 | | | | |
| 0.5 LAVM^2 | 0.0028 | 0.04 | | | 0.2687 | 2.25 | 0.2925 | 2.62 | 0.2679 | 2.22 |
| LAM*LWCM | 0.0960 | 2.32 | 0.1058 | 2.20 | 0.0581 | 1.08 | | | | |
| LAM*LTAM | 0.0147 | 0.19 | -0.0147 | -0.18 | -0.1413 | -1.30 | | | | |
| LAM*LAVM | 0.0376 | 2.72 | | | -0.0577 | -0.73 | | | | |
| LWCM*LTAM | 0.1202 | 2.09 | 0.1395 | 2.59 | 0.1361 | 1.36 | | | | |
| LWCM*LAVM | -0.0248 | -2.59 | | | 0.0115 | 0.14 | 0.0492 | 0.88 | 0.1176 | 1.87 |
| LTAM*LAVM | 0.0005 | 0.03 | | | -0.0569 | -0.51 | | | | |
| ***Control variables*** | | | | | | | | | | |
| PIA | 2.1831 | 4.09 | 2.1283 | 3.90 | 0.0234 | 0.01 | -0.1869 | -0.19 | 0.1429 | 0.15 |
| 0.5 PIA^2 | -3.5255 | -3.77 | -3.5245 | -3.67 | 0.6706 | 0.18 | 0.6326 | 0.31 | -0.2360 | -0.12 |
| LAM*PIA | -0.0140 | -0.12 | -0.0603 | -0.50 | 0.4239 | 2.14 | | | | |
| LWCM*PIA | 0.1416 | 1.76 | 0.1777 | 2.16 | 0.1103 | 0.92 | 0.1649 | 2.07 | 0.1156 | 1.31 |
| LTAM*PIA | -0.3120 | -2.26 | -0.3304 | -2.31 | 0.1083 | 0.23 | | | | |
| LAVM*PIA | 0.0387 | 1.57 | | | -0.4921 | -2.64 | -0.2414 | -1.11 | -0.0959 | -0.55 |
| DL3 | -0.1976 | -2.32 | -0.2325 | -2.75 | 0.0419 | 0.54 | | | | |
| DL4 | -0.4472 | -4.08 | -0.4940 | -4.42 | -0.1708 | -0.53 | | | | |
| DL5 | -0.2239 | -1.22 | -0.3825 | -2.06 | -0.3038 | -0.86 | | | | |
| Ln{\sigma_v} | -0.6900 | -14.1 | -0.6664 | -14.30 | -1.1555 | -6.14 | -1.0100 | -12.80 | -0.9445 | -13.10 |
| ***Inefficiency model*** | | | | | | | | | | |
| Constant | 3.1396 | 3.20 | 3.3650 | 3.40 | 1.1876 | 0.92 | 1.6201 | 1.70 | 5.3227 | 2.20 |
| LAM | 0.4370 | 2.21 | 0.5232 | 2.76 | 0.4070 | 1.74 | | | | |
| LWCM | 0.8463 | 3.18 | 0.7617 | 3.79 | 0.2379 | 1.28 | 0.3948 | 2.24 | 0.0185 | 0.09 |
| LTAM | 0.5564 | 2.14 | 0.5230 | 2.21 | 0.4153 | 1.15 | | | | |
| LAVM | -0.0302 | -0.52 | | | 0.0962 | 0.24 | 0.6643 | 2.55 | 1.5311 | 2.23 |
| DINDAP | -0.1279 | -0.36 | -0.3329 | -1.32 | -0.7296 | -2.71 | -0.7284 | -2.86 | -1.8455 | -2.75 |
| DMANAG | -0.1747 | -0.69 | -0.0734 | -0.32 | 0.7787 | 2.43 | 0.8710 | 3.20 | 2.4669 | 2.66 |
| DGL | | | | | -0.1776 | -0.59 | -0.1454 | -0.52 | 0.0033 | 0.01 |
| DEX | 1.0969 | 2.64 | 1.0935 | 2.74 | 0.3845 | 1.28 | 0.3454 | 1.28 | -0.5301 | -0.84 |
| POA | 0.4813 | 1.14 | | | -0.0604 | -0.15 | | | | |
| SHA | -7.2207 | -7.80 | -7.1318 | -7.46 | -1.1941 | -1.63 | -2.0985 | -2.64 | -3.8181 | -2.71 |
| ACC | -0.1045 | -2.03 | -0.1072 | -2.27 | 0.0231 | 0.84 | -0.0424 | -1.10 | 0.0110 | 0.19 |
| FS | -0.3028 | -3.20 | -0.2604 | -2.55 | -0.0379 | -0.35 | 0.0543 | 0.41 | 0.2131 | 1.15 |
| EDU | -0.0775 | -2.39 | -0.1026 | -2.70 | -0.0039 | -0.19 | -0.0276 | -1.08 | -0.0412 | -1.19 |
| AGE | 0.0089 | 1.11 | 0.0128 | 1.80 | -0.0145 | -0.82 | -0.0225 | -1.98 | -0.0502 | -2.25 |
| DCC | 0.8993 | 3.92 | 0.8113 | 3.17 | -0.7240 | -2.04 | -1.1054 | -3.19 | | |
| CRED | -0.5987 | -4.01 | -0.5894 | -3.75 | 0.2442 | 1.40 | 0.2368 | 2.06 | | |
| ***Generated regressors*** | | | | | | | | | | |
| *Fitted Probit* (DCC) | | | | | | | | | -5.6272 | -2.50 |
| *Fitted Tobit* (CRED) | | | | | | | | | 0.9902 | 2.11 |
| **LLF** | 270.08 | | -275.51 | | -54.07 | | -65.56 | | -63.16 | |
| **Parameters** | 42 | | 33 | | 42 | | 25 | | 25 | |
| **Mean Efficiency** | 0.89 | | 0.89 | | 0.74 | | 0.78 | | 0.84 | |
| **Var(u)/Var(Total)** | 0.40 | | 0.35 | | 0.65 | | 0.60 | | 0.40 | |
| **Chi-squared*** | 72.6 | | 69.4 | | 40.8 | | 44.1 | | 48.8 | |
| **Observations** | 342 | | 342 | | 109 | | 109 | | 109 | |

* This is a mixed Chi-squared test that involves inequality and equality restrictions. Koddle and Palm (1986) provide upper and lower bounds to evaluate its significance.

Source: Own calculations using survey data

$$e_{wc} = \frac{\partial \ln y}{\partial \ln x_{wc}} = \beta_{wc} + \omega_{wc} PIA$$

Thus, given that the parameter related to the variable LWCM*PIA is significant, we can estimate, at the sample mean level, the working capital elasticity of specialized crop producers with irrigation as

$$e_{wc} = \frac{\partial \ln y}{\partial \ln x_{wc}} = 0.5695 + 0.1777 \times 0.66 = 0.69$$

With regard to the inefficiency term, it is properly explained by the variables considered and the estimation improves when the variance of the inefficiency term is modeled (last two rows in **Table 22**). A general test for the importance of the one-sided term (inefficiency) can be based on the LR test between the ordinary last square estimate and the best model. Using this procedure, we reject the null hypothesis of no inefficiency because the statistic value is 69.42, which is larger than 23.6.[32]

**Table 22**
**Likelihood ratio tests for the crop production frontier model**

| $H_0$ The parameter of the variable(s) is(are) cero | LLF | Number of parameters | Number of restrictions (m) | LR | Critical Value $X^2$(m, 0.95) | Decision |
|---|---|---|---|---|---|---|
| **Full Model** | -270,08 | 42 | | | | |
| **Best Model** No animal market value[(1)] (all terms involving LAVM and DAV = 0), and no Tenure (POA = 0) | -275,50 | 33 | 9 | 10.84 | 16.9 | No Rejected |
| **No effect of credit market** (Terms involving CRED and DCC = 0) | -281,11 | 31 | 2 | 11.22 | 5,9 | Rejected |
| **Cobb-Douglas** (all cross effect terms = 0) | -294,08 | 23 | 10 | 37.16 | 18,3 | Rejected |
| **No Technical Effects** (all $\phi_j = 0$) | -304,02 | 20 | 13 | 57.04 | 22,3 | Rejected |
| **No Inefficiency** ($\sigma_0$ and all $\phi_j = 0$) | -310,90 | 18 | 14 | 69.42 | 23.6[(2)] | Rejected |

(1) Note that this variable appears in both the production function (LAVM and its interactions) and in the inefficiency model
(2) Koddle and Palm (1986)
Source: Own calculations using survey data

**Table 23**
**Regularity conditions for the crop production frontier model**

| Regularity conditions | Percentage of the sample | |
|---|---|---|
| **Monotonicity** | | |
| Land | 100% | |
| Working Capital | 100% | |
| Labor force | 83% | |
| **Quasi Concavity** | 100% | |
| **Linearity** | $X^2$ / $X^2$(m,0.95) | **Decision** |
| **Scale Constant Return** $\sum_{i=1}^{3} \beta_i = 1$ | 2.52 / 3.84 | **No Rejected** |
| **Homothetic** $\sum_{j=1}^{3} \beta_{ji} = 0$ | 15.35 / 7.81 | **Rejected** |

m= Number of restrictions
Source: Own calculations using survey data

32 The test involves inequality and equality restrictions so that the estimated LR test has a distribution mixed *Chi-square* random variable (Coelli and Battese, 1996). Koddle and Palm (1986) provide upper and lower bounds to evaluate its significance.

The mean inefficiency in the sample is 11% and most variables used to explain it are significant[33]. It is important to remember that those variables explain the variance of the inefficiency and in this way the mean inefficiency[34], so that a negative sign indicates a contribution to technical efficiency and vice-verse. Note also that we can directly interpret the parameters of the variables in the inefficiency model as their marginal effects because we have used the scaling property to model the inefficiency.

Results indicate that there is a positive relation between efficiency and education of head of family (EDU), age (AGE) of the head of family (experience), family size (FS) and the share of on-farm income in total income (SHA). Additionally, technical efficiency decreases with increasing use of inputs (LAM, LWCM and LTAM). Parameters related to extension services (DEX) and distance to a main road (ACC) are significant, but their signs are unexpected. Thus, farmers that receive extension and are located closer to a main road are less efficient. Those results suggest that the efforts of extension have not produced the effects expected and, on the contrary, have gone in an opposite direction, which could be explained by a bad quality of service and/or an inadequate implementation[35]. The second result could be related to two factors. First, although the distances are not considerable, farmers that are located far from a main road could be trying to compensate higher transport costs with higher levels of efficiency. Second, in the sample considered, farmers located farther tend to be smaller, implying, according to our previous results, higher levels of efficiency.

The variables related to *credit market* (CRED and DCC) are important in explaining technical efficiency and the hypothesis that they are not jointly significant is rejected, as shown in the third row of **Table 22**. The amount of credit (CRED) positively contributes to efficiency. This result is in line with the theories of free cash flow, credit evaluation, embodied capital and

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33 This value is not directly generated by the program. The software gives a score of efficiency for each unit, so the mean efficiency is just the mean of those values. Thus, the mean inefficiency is 1 minus the estimated mean efficiency. This procedure is followed by all the efficiency studies.

34 The expectation of a half-normal distribution can be expressed as

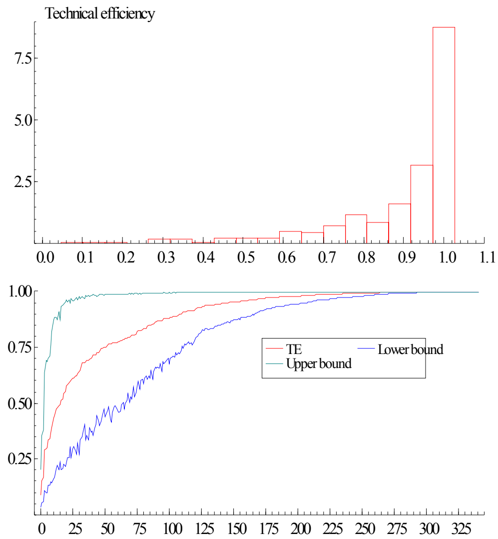
$$E(\mu) = \left( \frac{2}{\sqrt{\pi}} \sigma_u^2 \right)$$

35 In the sample, 15% of farmers had extension services which were basically financed by INDAP. In addition, there is some evidence that suggests that the extension program has increased productivity but, at the same time, the costs have increased by an increased inputs use (Lopez, 1996). However, our finding should be taken with caution because we are indeed measuring the efficiency on the value of total production and not on the physical amount of output.

credit as insurance. We assert that higher levels of credit relieve the necessities of financing to buy enough *levels* and the *optimal mix* of inputs in order to reach high levels of technical efficiency and the credits are spent on production activities. The condition of credit constraint (DCC) affects efficiency negatively, which can be explained because constrained farms can be unable to reach their suitable technological packages. However, as mentioned at the end of Section 4.2, Chapter IV, the results of technical efficiency are finally an empirical issue where both institutional factors and psychological reasons could help us to understand such a result.

The intervention of public policy, measured by the farmer participation in some INDAP programs (DINDAP), was not significant. Therefore, there are not differences in the levels of efficiency between farmers who participate in the program and those who do not[36]. Likewise, the variable related to management efforts (DMANAG) was not significant, showing that farmers who made some effort to improve their management did not achieve improvements on technical efficiency. On the other hand, the distribution of inefficiency is biased to farms with scores close to one and the confidence intervals are quite wide for the less efficient farmers (**Figure 6**). Finally, all previous results do not change after taking into account different estimations of labor force (**Appendix 2**).

**Figure 6**
**Distribution of efficiency and confidence intervals for specialized crop producers**




Source: Own calculations using survey data

36 Two dummies were separately incorporated in the estimations, but neither of them was significant. One of the dummies takes the value of one if any household member participates in some INDAP program and the other dummy takes the value of one if the farmer received or had received credit.

### 5.4.2 Specialized Livestock Production

Based on Columns 2 and 4 in **Table 21**, we presented in **Table 24** the LR tests. We can say that the best model does not include the variables land (LAM), labor force (LTAM) and localization (DL) in the production function and the variable related to land tenure (POA) in the inefficiency model. As mentioned, the sample includes different kinds of animal production with a clear dominance of cattle production, which is located in macro zone 5. Consistent with this, the number of equivalent animals per hectare in macro zone 5 is just 1.2 in comparison with 5 in macro zone 3, which is basically explained by a higher availability of land. This characteristic would apparently suggest that production function would not be influenced by the available land, which is supported by several empirical applications, where the variable is not incorporated in production function or the parameter estimate is not significant (Brummer, 2000; Kumbhakar *et al.*, 1991; Tauer L, 2001; Bravo-Ureta *et al.*, 2006; Bravo-Ureta and Rieger, 1991; and Tauer and Mishra, 2006). Moreover, no relevance of labor force could be a consequence of using a biased estimation of the variable or it can simply be a characteristic of livestock production in small farmers[37]. This result has been observed as well in some studies such as Brummer (2000) and Brummer *et al.* (2002).

**Table 24**
**Likelihood ratio tests for the livestock production frontier model**

| **H0**<br>**The parameter of the variable(s) is(are) cero** | **LLF** | **Number of parameters** | **Number of restrictions m** | **LR** | **Critic Value $X^2$(m, 0.95)** | **Decision** |
|---|---|---|---|---|---|---|
| **Full Model** | -54.00 | 42 | | | | |
| **Best Model**<br>No labor force, land(1), dummy of localization, and tenure<br>(LTAM, LAM, DL, and POA = 0) | -65,56 | 25 | 17 | 23.72 | 27.58 | No rejected |
| **No Credit Market**<br>(CRED and DCC) | -70,43 | 23 | 2 | 9.74 | 5.99 | Rejected |
| **Cobb-Douglas**<br>(all cross effect terms = 0) | -78,08 | 19 | 6 | 25.04 | 12.59 | Rejected |
| **No Inefficiency Effects**<br>(all $\phi_j = 0$) | -85,99 | 12 | 13 | 40.86 | 22.36 | Rejected |
| **No Inefficiency**<br>($\sigma_0$ and all $\phi_j = 0$) | -87,59 | 10 | 14 | 44.06 | 23.68(2) | Rejected |

(1) Note that the variables LTAM and LAM appear in both the production function (alone and their interactions) and the inefficiency model
(2) Kolldle and Palm (1986).
Source: Own calculations using survey data

37 In the full model the parameters estimated for LAM and LTAM are 0.14, and 0.20, with standard deviations of 0.12, and 0.19, respectively.

The Cobb Douglas representation is not appropriate and the technology translog has a better representation of the data (Fourth row in **Table 24**). Analysis of regularity conditions in **Table 25** shows that the technology is characterized by monotonicity in the two inputs considered (working capital and animal market value) and quasi concavity, measured in the input working capital, is fulfilled in 99% of the cases in the sample. Additionally, the technology is not homothetic and the hypotheses of constant return to scale, at sample mean level, was rejected, finding increasing return to scale (1.35), which suggests that farms in the sample are operating at a sub-optimal size. A discussion about the optimal size of cattle producers has emerged during the last years in Chile, as a consequence of the strong competitiveness with imported meat from MERCOSUR and, therefore, this result reinforces this discussion.

**Table 25**
**Regularity conditions for the livestock production frontier model**

| Regularity conditions | | Percentage of the sample | |
|---|---|---|---|
| **Monotonicity** | | | |
| Working Capital | | 100% | |
| Animal market value | | 98% | |
| **Quasi Concavity** | | 99% | |
| **Linearity** | | **$X^2$ / $X^2$(m,.0.95)** | **Decision** |
| Scale Constant Return | $\sum_{i=1}^{2} \beta_i = 1$ | 12.21 / 3.84 | **Rejected** |
| Homothetic | $\sum_{j=1}^{2} \beta_{ji} = 0$ | 21.56 / 5.99 | **Rejected** |

m= Number of restrictions
Source: Own calculations using survey data

The parameter estimates of the best model (Column 4 in **Table 21**) show that the partial elasticities of working capital and animal market value, evaluated at sample mean level, are significant with values of 0.51 and 0.84, respectively. The variable related to irrigation (PIA) is not significant, implying that there is no difference between land with and without irrigation; however, from a statistical point of view, the interaction of proportion of irrigated land and necessities of working capital (LWCM*PIA) is important. Thus, the necessities of working capital of one hectare with irrigation would be equal to 0.55, slightly higher that a hectare without irrigation (0.51)[38].

The inefficiency is properly explained by the variables considered, and model estimation

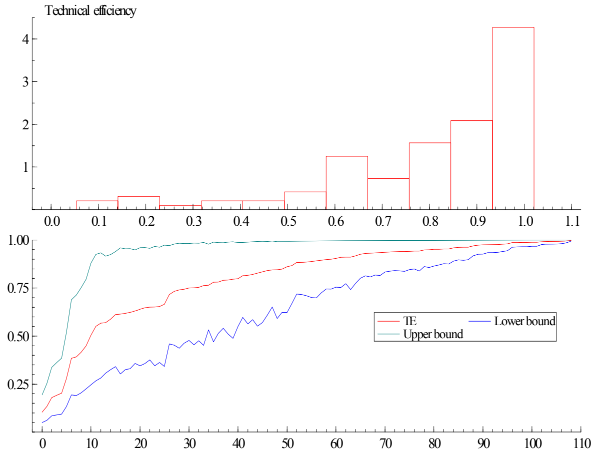
38 The mean of proportion of irrigated land in the sample is 20%, which is strongly influenced by the macro zones 2 and 3, which are less intensive zones in livestock production.

improves when the variance of the inefficiency term is modeled, because we rejected the null hypothesis of no inefficiency with a statistic of 44.06 (last rows in **Table 24**). The mean inefficiency is 22%, and the results indicate that when household income depends more strongly on its on-farm income (SHA), the head of family is more educated (EDU) and has more experience (AGE), then the farmer is expected to be more technically efficient. Another interesting finding is that technical efficiency decreases with increasing use of inputs (LWCM and LAVM).

The variables related to credit market are important in explaining the technical efficiency and the hypothesis that they jointly are not significant is rejected, as shown in the third row of **Table 24**. The amount of credit (CRED) and the condition of constrained (DCC) contribute negatively and positively to technical efficiency, respectively (Column 4 in **Table 21**). The negative impact of credit on efficiency is in line with the theories of agency cost and adjustment; however, we believe that those results could be more suitably explained by low development of the credit market in the sector. Since the beginning of 2000, the prospects of livestock production have improved, which could have been forcing to producers to make investments by using credit of short run because of the lack of credits of long run. In this context, credit could have been used in activities that do not necessarily have an impact on annual production. On the other hand, the condition of credit constraint (DCC) positively contributes to efficiency, which could be explained because farms constrained could put more effort towards achieving their goals.

The intervention of public policy, measured by the farmer participation in some INDAP program (DINDAP), is significant, showing evidence of differences in the levels of efficiency between those who participate and those who do not. This result could be explained by policy efforts of the most recent years in this sector. The variable related to management efforts (DMANAG) is significant but its sign was contrary to what is expected. Farmers that spend some of their money on management are less efficient than those who do not. This result could be showing some problems related to the type of effort or erroneous practices. On the other hand, the distribution of inefficiency is biased to farms with scores greater than 0.6 and farmers less efficient (one-third of the sample) show quite wide confidence intervals (**Figure 7**). Finally, all previous results do not change after taking into account different estimations of labor force (**Appendix 3**).

**Figure 7**
**Distribution of efficiency and confidence intervals for specialized livestock producers**



Source: Own calculations using survey data

### 5.4.3 Is there endogeneity in the financial variables?

We estimated a Tobit model for the variable credit (CRED) and a Probit model for the variable credit constraint (DCC), and their results are presented in **Appendix 4**[39]. From those estimations, we got their residuals and incorporated them into our model as a new variable. Then we checked the significance of its parameter in order to test simultaneity.

**Table 26** shows the results of the Durbin-Wu-Hausman test. According to the LR test, we can not reject the hypothesis of no simultaneity in crop production but we can reject it in livestock production. What could explain this simultaneity?. From an institutional perspective, a plausible explanation could be related to the knowledge that lenders have about farms. The sample analyzed shows that the main lenders are INDAP and Banco Estado, two institutions with a long tradition of support of smallholders. Since beginning of this decade, INDAP has been developing networks with livestock-oriented farmers, and at a minor level, the Banco Estado has been as well, not only by the direct delivery of promotion instruments but also by gathering better levels of information about farmers. This characteristic has not appeared in crop production because it is believed that this sector has low development prospects in the future and is a sector without an exporting orientation. We believe that it has produced important differences between both sectors.

[39] We are interested in the effects of potential simultaneity of the financial variables on technical efficiency and we do not analyze in detail the results obtained from the Tobit and Probit models.

**Table 26**
**Durbin-Wu-Hausman Test**

| $H_0$<br>**The parameter of the variable(s) is(are) cero** | **LLF** | **Number of parameters** | **Number of restrictions m** | **LR** | **Critic Value $X^2$(m, 0.95)** | **Decision** |
|---|---|---|---|---|---|---|
| Best Model in Specialized Crop Production | -275,50 | 33 | | | | |
| No simultaneity (Residuals from Tobit and Probit) | -274.80 | 35 | 2 | 1.4 | 5.99 | No rejected |
| Best Model in Specialized Livestock Production | -65.56 | 25 | | | | |
| No simultaneity (Residuals from Tobit and Probit) | -58.94 | 27 | 2 | 13.24 | 5.99 | Rejected |

Source: Own calculations using survey data

Column 5 in **Table 21** presents corrected estimations of livestock production, considering the fitted values of the Tobit and Probit estimations as instruments of the financial variables. The idea is to check if the parameters of the instruments remain significant and with the previous signs. We can see that they maintain their significance and signs, which confirm our previous results. However, this procedure affected some parameters of the model. In the production function, the elasticity of animal market value (LAVM) increased, the elasticity of working capital (LWCM) decreased, the proportion of irrigated land was no longer significant, and the interaction between inputs (LWCM and LAVM) was significant and positive, suggesting a complementary relationship between them. In the inefficiency model, the variable working capital was no longer significant, and the parameters of the instruments used increased in magnitude. Those results suggest that it is very important to check and to correct for endogeneity, which is clearly observed when one views the parameter of the variable working capital. Thus, when the model with endogeneity is estimated, the parameter of that variable is inconsistent; however, after being corrected, its parameter strongly changes not only in its magnitude but also in its significance. Therefore, we have to stress the necessity of checking simultaneity in the *variables that model the inefficiency effects*.

# Chapter VI

# Technical Efficiency and Off-farm activities among Non-specialized Small Farmers

## 6.1 Motivation

The Chilean small farmers face a complex situation as a result of a more intensive open trade process in recent years. Additionally, it is clear that the living conditions of the rural inhabitants depend more strongly on off-farm earnings. In this context, public policy has many challenges, on the one hand, to enhance a higher level of productivity at the farm level and, on the other, to provide development instruments in post non-farm activities in rural areas. This challenge is really hard, especially when rural development is not a national priority.

It is a fact that farm households across the developing world earn an increasing share of their income from non-farm sources. Barrett *et al.* (2001) analyzed the non-farm income diversification and household livelihood strategies in rural Africa, Reardon *et al.* (2001) studied the situation in Latin America, Chaplin *et al.* (2003) provided information about non-agricultural farm diversification in Central European countries, Fernandez-Cornejo *et al.* (2007) focused on the United States. In order to improve public policy Readon *et al.* (2006) remarked on the necessity of understanding the nature and patterns of household income diversification, and distinguished the factors that drive households into non-farm activity.

Berdegue *et al.* (2001) is the known unique study that deals with non-farm incomes for the Chilean case. They analyzed the evolution of rural non-farm income and employment in Chile from 1990 to 1996 and showed that during this period rural non-farm income increased 18% and accounted for 41% of the rural income while rural non-farm employment increased 10%, reaching 39% of rural employment. However, there is no research that has studied efficiency of farmers and its relation with participation in off-farm activities.

The main question is whether the technical efficiency of small farmers is affected by the decisions of participation in off-farm activities or not, and if so, what kind of relationship exist?. This issue has not been deeply studied in the literature although its importance is clearly fundamental. The few studies are not conclusive and are based on different methodologies which make a difficult comparative analysis.

Based on data at the farm level, we formulate and estimate technical efficiency for small non-specialized Chilean farmers by using stochastic frontier analysis, considering heteroscedasticity in the inefficiency estimated and endogeneity in the decisions of participation in off-farm activities. We focus on farmers that have some grade of diversification in their agricultural production mix because we are also interested in studying how this diversification affects the levels of efficiency. In this way we could get some insights about how the agricultural production structure affects the scores of technical efficiency.

From an empirical point of view, the study provides four contributions. First, this study will be the first one in Chile that deals with estimations of technical efficiency and technological parameters of small farmers by using a country wide sample for non-specialized producers.

Second, the production technology of farmers is modeled by taking into account differences in partial production elasticities among different sectors. Few studies have dealt with multi product technologies (Bravo-Ureta *et al.*, 2007) due to the difficulties in its modeling. The literature reviewed has used dummy variables by modeling different intercepts among sectors (O'Neill and Matthews, 2001, Rezitis *et al.*, 2002, and Dong, 1997) without taking into account differences in the partial production elasticities which clearly lose valuable information of the underlying technologies.

Third, the variance of the inefficiency term is modeled instead of its mean. The few studies that have followed this method are basically focused on agriculture of higher size. Thus, this research contributes by analyzing to small farmers and incorporating a wide range of variables to explain the variance of the inefficiency term.

Fourth, using a framework of stochastic frontier analysis, the statistical relation between technical efficiency and participation in off-farm labor is studied by considering the potential endogeneity of the participation.

## 6.2 Model specification and data analysis

### 6.2.1 Model specification

Based on the on-farm income of each activity a Herfindahl index was built and the grade of specialization of each farmer was identified, taking those farmers with an index smaller than 1. Thus, we got a final sample composed of 384 non-specialized producers (see Chapter IV).

The sample was divided into three subgroups depending on the grade of orientation in the production. Dummy variables were used to do that. DLIVE takes the value 1 if livestock income share is equal or larger than 70%, DCROP takes the value 1 if crop income share is equal or larger than 70%, and DMIX takes the value 1 if there is not any production activity with an income share greater than 70%. In other words, DMIX measures farmers that are not specialized at all.

Similar to Chapter V, the technology is represented by a Translog production function as follows

$$\log y = \beta_0 + \sum_{i=1}^{4}\beta_i \log x_i + \frac{1}{2}\sum_{i=1}^{4}\sum_{j=1}^{4}\beta_{ij}\log x_i \log x_j + \alpha_1 PIA + \sum_{k=1}^{4}\omega_k PIA \log x_k + \sum_{m=1}^{4}\lambda_m Dcrop \log x_i + \sum_{n=1}^{4}\psi_n Dlive \log x_i + \sum_{d=1}^{4}\phi_d D_d + \nu - \mu$$

where β, α, ω, λ, φ and *Φ* are unknown parameters, $v_i$ is a pure random term (white noise) and $u_i$ is a systematic, nonnegative error term accounting for efficiency. The dependent variable is the weighted on-farm total income using as weights the shares of each activity (crop, livestock, fruit and vegetables), and log y is the decimal logarithm of this variable. As was defined in Chapter V, Log x is the decimal logarithm of four inputs; used land (A), working capital (WC), the market value of livestock (AV), and the input estimated family labor force (T). We use three additional variables to take into account differences in the quality of soil (PIA), localization of the farms (DL2, DL3, DL4, and DL5), and potential bias of the parameters estimated in the production function (DAV). Additionally, two new variables are added; DCROP and DLIVE which are dummy variables that capture the differences in the production orientations among farmers, incorporating them as intercepts and slopes in the production function. Thus, the parameter $\beta_0$ represents the mean on-farm income level of a diversified farmer that is located in macro zone 2.

Most of the signs expected were discussed in Chapter V; however, the signs expected of the new variables (DCROP and DLIVE) both in the intercepts and in the slopes (DCROP*log x and DLIVE*log x) are indeterminate *a priori.*

The inefficiency model is discussed in Chapter V, and is formulated as follows

$$\log \sigma_{\mu} = \sigma_0 + \sum_{j=1}^{16} \phi_j z_j + \xi$$

where $\phi_j$ are parameters to be estimated that measure the influence of variables in z on efficiency, and $\xi_i$ are independent and identically distributed (*i.i.d.*) normal random variables with a mean of zero and constant variance.

The vector *z* represents factors that influence efficiency which includes several categories of variables. Three variables account for socioeconomic characteristics of the farm household (AGE, EDU, and FS), One variable related to tenure (POA), one variable measures access to markets (ACC), one variable that represents public policy (DINDAP), on variable associated with credit market (CRED), and ten variables that capture management decisions (A, WC, AV, T, DMANAG, DEX, SHA, DCROP, DLIVE and DOFF). The dummy variable DOFF measures the participation of farm in off-farm activities, taking the value 1 if the household participates. Notice that the intercept in the inefficiency model is the mean variance of a diversified farmer (DMIX).

According to Section 3.2.5, Chapter III, the sign of the relation between participation in off-farm activities and technical efficiency is ambiguous, so we formulate no *a priori* expectations for this variable[40]. On the other hand, DCROP and DLIVE should have a negative effect on efficiency if efficiency increases with a higher on-farm production diversification.

[40] Participating in off-farm activities can either increase efficiency by means of relieving financial restrictions or reduce efficiency as a result of a lower effort of farmers on farms.

### 6.2.2 Data analysis

The descriptive statistics of the sample are given in **Tables 27, 28** and **29.** According to our definition of farmer, the mixed, crop-oriented and livestock-oriented producers account for 42%, 29% and 27% of the sample, respectively. They are concentrated in macro zone 4 and 5 with more than 80% of the sample. Moreover, on average, 40% of farmers get credit of short term, basically financed by INDAP (72%), Banco Estado (14%), and Oriencoop (3%). For those farmers that can get credit, it accounts for between 28% and 41% of their financing.

**Table 27**
**Descriptive statistics of non-specialized producers**
**(sample: 384 observations)**

| Variable | Minimum | Mean | Maximum | Std.Dev |
|---|---|---|---|---|
| **Production Function** | | | | |
| Y | 104 | 1,639 | 18,450 | 2,353 |
| A | 0.30 | 21.39 | 220 | 27.45 |
| WC | 60 | 1,683 | 59,75 | 3,829 |
| TA | 6.06 | 90.06 | 350.64 | 46.62 |
| AV | 0 | 2,086 | 12,300 | 1,978 |
| DAV | 0 | 0.99 | 1 | 0.08 |
| **Specialization** | | | | |
| DMIX (165 farmers) | 0 | 0.43 | 1 | 0.49 |
| DCROP (115 farmers) | 0 | 0.30 | 1 | 0.45 |
| DLIVE (104 farmers) | 0 | 0.27 | 1 | 0.44 |
| **Control variables** | | | | |
| DL2 | 0 | 0.05 | 1 | 0.21 |
| DL3 | 0 | 0.07 | 1 | 0.26 |
| DL4 | 0 | 0.34 | 1 | 0.47 |
| DL5 | 0 | 0.52 | 1 | 0.49 |
| PIA | 0 | 0.21 | 1 | 0.36 |
| **Public Policy** | | | | |
| DINDAP | 0 | 0.68 | 1 | 0.46 |
| **Management** | | | | |
| DMANAG | 0 | 0.47 | 1 | 0.49 |
| DEX | 0 | 0.25 | 1 | 0.43 |
| SHA | 0.04 | 0.57 | 1 | 0.31 |
| DOFF | 0 | 0.55 | 1 | 0.49 |
| **Credit Market** | | | | |
| CRED | 0 | 0.25 | 10 | 0.69 |
| DCRED | 0 | 0.40 | 1 | 0.49 |
| **Access to market** | | | | |
| ACC | 0 | 1.48 | 30 | 3.09 |
| **Socioeconomic** | | | | |
| FS | 1 | 3.68 | 12 | 1.86 |
| AGE | 24 | 54.32 | 95 | 14.38 |
| EDU | 1 | 7.43 | 26 | 5.45 |
| **Tenure** | | | | |
| POA | 0 | 0.63 | 1 | 0.44 |
| **Instruments** | | | | |
| Y/FS | 26.70 | 539.12 | 9,066 | 886.82 |
| OTHERINPC | 0 | 118.94 | 2,880 | 225.79 |
| OA | 0 | 15.09 | 220 | 26.21 |
| DOPR | 0 | 0.27 | 1 | 0.44 |
| INDEX | 0.38 | 0.64 | 0.97 | 0.13 |
| CS | 1 | 1.29 | 4 | 0.49 |
| DINDTYPE | 1 | 2.24 | 3 | 0.92 |
| TST | 1 | 25.00 | 125 | 17.40 |
| INC2000 | 1 | 3.65 | 5 | 0.90 |
| DEPCHILD | 0 | 0.15 | 0.66 | 0.19 |
| DEPOLDP | 0 | 0.79 | 5 | 0.84 |
| MFS | 0 | 0.55 | 1 | 0.21 |
| DSEX | 0 | 0.80 | 1 | 0.39 |

Source: Own calculations using survey data

A 55% of the sample participates in off-farm activities and, on average, the off-farm income represents 33% of their income sources. At the type of producer level, it is possible to see that for those farmers that participate in off-farm activities, the group of crop-oriented producers has the lowest participation (27%) and the group of mixed producer has the highest one (62%) Additionally, it is remarkable the fact that when farmers are unable to get formal credit, the informal credit market does not provide the necessary funds and the selling of fixed asset and the owned resources become very important.

**Table 28**
**Financing sources of working capital with and without formal credit by sub group**

| Status | Sub sector | Formal | Informal | Selling of Fixed Assets | Own Resources (1) | Others (2) | Total working capital |
|---|---|---|---|---|---|---|---|
| With Credit | DMIX | 28.4% | 2.3% | 1.6% | 59.3% | 8.3% | 100% |
| | DCROP | 41.1% | 3.6% | 1.2% | 50.1% | 4.0% | 100% |
| | DLIVE | 40.5% | 0.7% | 0.8% | 46.9% | 11.1% | 100% |
| Without Credit | DMIX | 0% | 1.0% | 2.0% | 82.8% | 14.3% | 100% |
| | DCROP | 0% | 6.9% | 1.2% | 82.4% | 9.6% | 100% |
| | DLIVE | 0% | 0.4% | 3.7% | 80.6% | 15.3% | 100% |

(1) Includes seeds, savings, rented land, profits from previous season and selling of animals
(2) Any item that is not included in the others, for example, pensions and income from off-farm activities
Source: Own calculations using survey data

**Table 29**
**Share of the income sources with and without participation in off-farm activities by sub group**

| | Sub Group | On-farm | Off-farm | Other Income (1) | Total Income |
|---|---|---|---|---|---|
| Sample mean | | 55% | 33% | 12% | 100% |
| Participate in off-farm activities | DMIX | 29% | 62% | 10% | 100% |
| | DCROP | 65% | 27% | 8% | 100% |
| | DLIVE | 42% | 52% | 7% | 100% |
| No Participate in off-farm activities | DMIX | 73% | 0% | 27% | 100% |
| | DCROP | 87% | 0% | 13% | 100% |
| | DLIVE | 72% | 0% | 28% | 100% |

(1) It basically includes subsidies and pensions.
Source: Own calculations using survey data

## 6.3 Dealing with endogeneity[41]

As analyzed in Chapter III, the amount of credit could be determined by the performance of farmers in the use of their inputs (technical efficiency). Additionally, the same chapter shows that this theme has been lightly studied in the literature, and in Chapter V, endogenity was

41 The estimation procedure is discussed in Section 5.3.1, Chapter V.

tested and its presence confirmed in specialized livestock producers. This chapter again checks the potential endogeneity of credit; however, we focus on non-specialized farmers.

Moreover, this chapter wants to study the potential simultaneity of the variable participation in off-farm activities (DOFF) with the level of efficiency. The justification is based on the fact that more efficient farms would be expected to have higher relative returns to farm labor and thus would be expected to have less incentive to participate in off-farm activities. In other words, simultaneity between efficiency and participation in off-farm activities is possible since increased off-farm activities might decrease returns to purchased inputs if there is complementarity between labor and purchased inputs (Mishra and Goodwin, 1997).

On the other hand, based on the literature of selection models, a household's decision to participate in off-farm activities is dependent on the observable and unobservable characteristics of farms and farmers, this comes out in the fact that a household's decision is based on each farmer's self-selection instead of on random assignment (Heckman, 1978, 1979). This situation drives us to the endogenous treatment effect models (Wooldridge, 2003; and Maddala, 1983) because the variable of participation is, indeed, endogenous and any estimation technique failing to acknowledge and model this nonrandom selection may bias the estimates. The idea is simple: unobservable variables could be affecting both the efficiency and the probability of participation in off-farm activities; for example, managerial abilities could be conditioning the decision to participate and the efficiency level. Thus, able managers will tend to be better able to organise themselves so that they are able to find and hold off-farm work, and they will also tend to be more efficient.

In both cases, *simultaneity* or *self-selectivity*, the statistical problem is that the error terms that model the variance of the inefficiency might be correlated with the variable DOFF. Hence it is necessary to use an estimation procedure that either eliminates this correlation or measures and includes the correlation in the regression.

If there is evidence of endogeneity, instrumental variables ought to be used; otherwise our estimates would be inconsistent (Wooldridge, 2003). However, one alternative method to instrumental variables would be to use a restricted Control Function estimator based on Heckman (1978, 1979)[42]. Both techniques produce consistent estimates of the parameter

[42] The estimated parameters would be equivalent between restricted Control Function and instrumental

related to the variable DOFF, and the Control Function estimator is at least as efficient as instrumental variables (Vella and Verbeek (1999) pag. 475).

Just a few studies in agriculture have used those methods. In relation to credit, Kandker and Faruqee (2003) used instrumental variables to measure the impact of farm credit on different outcomes in Pakistan. Liu and Zhuang (2000) investigated the impact of liquidity, measured as the sum of available financial resources, on technical efficiency in a stochastic approach. Although the endogeneity was not tested, they replaced the variable of liquidity by its predicted values, which were obtained from an auxiliary regression of the variable of liquidity on a group of instruments. Habib and Ljungqvist (2005), in the finance field, studied the relation between the shortfall in market value of a firm, interpreted as inefficiency, and some variables related to incentives of managers. After checking for endogeneity, they could not reject the null hypothesis of no endogeneity of the variables studied.

Section 3.2.5 in Chapter III reviews the empirical applications with regard to efficiency and participation in off-farm activities, and it was noticed that there is not research that has considered endogeneity of the household decisions to participate in off-farm activities. On the other hand, in a different line of research Zavale *et al.* (2005) studied the impact of improved maize seed adoption on the smallholders' cost efficiency in Mozambique by using the restricted Control Function approach.

We use the Durbin-Wu-Hausman test (Davidson and MacKinnon, 1993) to check endogeneity. First, we run a regression of the potential endogenous variable on all the exogenous variables and a *set of instruments*. This considers both the instruments of the variable credit and the instruments of the variable participation in off-farm activities, which could perfectly overlap. The instruments should be variables highly correlated to the potential endogenous variables but not with the term error of the original inefficiency model. Second, we run the original model by incorporating the residuals of the previous regression and check the significance of their parameter. The null hypothesis is no endogeneity, which means that the parameters of the residuals should not be significant. Third, if there is evidence of endogeneity, we correct the estimations by using *fitted values* of each model as the instrument of the variable of interest, which follows in spirit the method of two-stage least squares.

variables under certain assumptions: normality, and if the response of treatment does not vary among treated and untreated (Wooldridge, 2003, pages. 621-623; and Vella and Verbeek, 1999, pages. 474-475).

Given the nature of the variables, we estimated a Tobit model for the variable credit (Cred) and a Probit model to the decisions of participation on off-farm activities (Doff). We are interested in the effects of potential simultaneity of the variables analyzed on the technical efficiency and we do not analyze in detail the results of the estimations Tobit and Probit.

After checking the literature, the instruments used to the variable credit are the following: The logarithm of on-farm income per capita (L[Y/FS]), which is used as a proxy of household wealth; the idea behind this variable is that high levels of household wealth could decrease the necessity of borrowing. The quantity of owned land (OA), used as a proxy of collateral, is expected to be a signal of guarantee for the lenders, increasing the chances of getting credit. The dummy variable relationship with productive organization (DOPR) is used as a proxy of social capital, understanding that the social-productive networks contribute to the access to credit. Additionally, we use three variables, from lender perspective, as proxies of a client's potential quality; the variable credit scoring (CS) ranks the lender perception regarding the borrower, taking continuing values between 1 and 4, being 4 the worst evaluation. This procedure is in line with practices that some banks have been implementing in recent years to minimize the administrative costs of delivering rural credits. We assumed that a better evaluation increases the probability of lending money, increasing the probability of borrowing for the farmer. Another variable considered is the payment behavior of farmers (DINDTYPE), measured as a categorical variable, taking values of 1, 2 and 3, with 1 being the best category. This variable can be used as a signal of client quality in the future and low values of this variable would be associated with higher possibilities of getting credit. Finally, we used the Herfindahl index (INDEX) to measure the grade of specialization in the on-farm production. Thus, the lender would take this information as a measure of diversification of farmers. Definitions of each variable and descriptive statistics are provided in **Tables 27** and **30**.

It is important to keep in mind that the expected effects mentioned in the previous paragraph are on the result of getting credit. However, the amount of credit is the result of the *interaction between demand and supply*, so we can not expect that those effects are an absolute truth, at least in some of the variables mentioned, and they can possibly go in the opposite direction.

**Table 30**
**Instruments for the variable credit (CRED)**

| Variable | Definition | Type | Proxy |
|---|---|---|---|
| Logarithm of on-farm income per person | L(Y/FS) | Continue | Wealth |
| Own land | OA | Continue (hectares) | Collateral |
| Relationship with productive organization | DOPR | Dummy 1 if farmer belong to productive organization | Social Capital |
| Credit score | CS | Continue between 1 and 4, where 1 is the best | Lender Perception |
| Payment behavior of farmers | DINDTYPE | Categorical. 1,2 and 3, where 3 is the worst | Signaling |
| Index of specialization | INDEX | Continue | Diversification |

L indicates log form
Source: Own definition

**Table 31**
**Instruments for the variable participation in off-farm activities (DOFF)**

| Variable | Definition | Type | Proxy |
|---|---|---|---|
| Logarithm of on-farm income per person | L(Y/FS) | Continue | Farm profitability |
| Other income source per person (subsidies and pensions per person) | OTHERINCP | Continue | Exogenous income |
| Perception of on-farm income with respect to the situation in 2000 | INC2000 | Categorical: 1, 2, 3, 4, 5, where 5 is the worst perception. | Expectations of the profitability of on-farm income |
| Total of years study of the household (include all members) | TST | Continue | Education |
| Dependence of children (ratio number of children to family size) | DEPCHILD | Continue | Demographic structure of the household |
| Dependence of old people (ratio number of people older than 60 years to family size) | DEPOLDP | Continue | Demographic structure of the household |
| Importance of males in the household (ratio number of males to family size) | MFS | Continue | Demographic structure of the household |
| Sex of head of family, taking value 1 if the head of family is male | DSEX | Dummy | Demographic structure of the household |

L indicates log form
Source: Own definition

To choose the instruments of the decision of participation in off-farm activities, we follow the conceptual framework discussed in Section 3.1.3, Chapter III. Most studies use demographic characteristics and income sources to explain the probability of participation. We use the logarithm of on-farm income per capita as a proxy for the farm profitability (L(Y/FS)), assuming a negative relationship between participation and on-farm profits. The same effect is expected with the variable other incomes per capita (OTHERINCP), actuating this as a level of exogenous income basically explained by the direct support from the government by subsidies. Additionally, we use the farmer perception with regard to the trend of the profitability of the on-farm incomes (INC2000). Thus, farmer reveals his expectation about how good the business has been during the last years, in particular regarding 2000. This is a categorical variable and higher values indicate a worse evaluation of business (on-farm incomes) and, therefore, a negative relationship with the decision of participation. Moreover, the years of schooling of the household (TST) are used to check the intuition that high levels of education are associated with a higher probability of entering into off-farm activities. Finally, three types of variables related to demographic characteristics of the household are used: sex (DSEX), dependence of children (DEPCHILD), dependence of old people (DEPOLDP), and importance of males in the household (MFS). Definitions of each variable and descriptive statistics are provided in **Tables 31** and **27.**

## 6.4 Estimations and discussion

**Table 32** depicts the results of the different estimations carried out. The estimations that do not take into account endogeneity of the variables credit and participation in off-farm activities are shown in the first and second columns. In the first one, we show the full model and the second one presents the best model. The LR tests show us that the best model does not include several variables, where the variable used land (LAM) was not significant in any estimation, either individually or in their interactions[43]. In the best model (Column 2 in **Table 32)**, the proxies of intermediate inputs (working capital), capital (animal market value) and labor (estimation of family labor force) are the variables that statistically explain the production under a translog production function, rejecting a specification Cobb Douglas (Column 1 in **Table 33**). Moreover, the analysis of the regularity conditions shows that the technology satisfies monotonicity and quasi-concavity, and the hypothesis of constant return to scale was not possible to reject at sample mean.

Different technology orientations have been checked in the sample by taking into account both the mean of levels of production (dummies in the intercepts) and their elasticities (dummies in the slopes). We found that there is a difference among producers not only in their mean levels of production but also in their production structures. Thus, taking the mixed producers as a reference, we can say that the livestock-oriented producers have lower levels of mean on-farm income than mix producers, and the crop-oriented producers get higher mean on-farm incomes than the mixed producers.

On the other hand, the partial production elasticities of working capital, labor force and animal market value, at sample mean level, are significant for each kind of producer.

[43] This could be explained because we are modeling the production value that includes several types of products, some of them more intensive in land than others and with different market values.

However, there are differences among them confirming our suspicions. It is even possible in some cases to observe differences caused by the availability of irrigation. **Table 34**, in Columns 1, 3 and 5, depicts the partial production elasticities estimated[44].

The control variables used in the modeling of the production function show that the localization is an important factor to explain differences in the mean of the on-farm incomes. Effectively, independently of the kind of producer (mixed, crop-oriented or livestock-oriented), the farmers located in the macro zones 4 and 5 can get lower levels of on-farm income than anywhere in Chile. On the other hand, the variable related to irrigation (PIA) makes differences in productivity between land with and without irrigation. However, given that we are considering different kinds of producers (mixed, crop-oriented and livestock-oriented) in a single technology, we can not directly see it, because we need first to estimate the partial production elasticity of the input land used (LAM) for each group of producers. For example, in the case of the mixed producers, one hectare with irrigation is more than 5.2 **t**imes more productive than one without irrigation[45].

With regards to the inefficiency, the tests conducted show that it is properly explained by the variables considered and the estimation improves when the variance of the inefficiency term is modeled **(Table 33,** Columns 2 and 3). A general test for the importance of the one-sided term (inefficiency) can be based on the LR test between the ordinary last square estimate and the best model. Thus, using this procedure, we rejected the null hypothesis of no inefficiency because the statistic value is 77.32, which is larger than 14.85.

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44 We can define the working capital elasticity in crop-oriented producers with irrigation as

$$e_{wc} = \frac{\partial Lny}{\partial Lnwc} = \beta_{wc} + \sum_{i=1}^{3} \beta_{wcj} \ln x_j + \lambda_{wc} Dcrop + \omega_{wc} PIA$$

If we evaluate this at the mean sample level, we have

$$e_{wc} = \frac{\partial Lny}{\partial Lnwc} = \beta_{wc} + \lambda_{wc} Dcrop + \omega_{wc} PIA$$

where *PIA* is the mean value of PIA in the crop-oriented producers. Thus, if the parameters are significant, the value is

$$e_{wc} = \frac{\partial Lny}{\partial Lnwc} = 0.3827 + 0.1364 * (1) + 0.1845 * (0.3) = 0.57$$

45 From footnote 19, we know that Log y = Constant + $\beta_1$ Log (Land) +$\beta_2$ (IL/Land), where $\beta_2 = \beta_1(\Phi_1 - 1)$ and $\phi_1$ is the value of one hectare of irrigated land in terms of unirrigated land. However, we need to have the parameter of the partial production elasticity of used land, which is not reported in Column 2 of **Table 32** because it was not significant. Its value is 0.053, which we used to generate 5.2 [{0.276/0.053} + 1].

## Table 32
## Stochastic production frontier results for small non-specialized producers

| Variables | No checking endogeneity | | | | Checking endogeneity | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Full Model | | Best Model | | Testing endogeneity | | Full Model | | Best Model | |
| | (1) | | (2) | | (3) | | (4) | | (5) | |
| | Coefficient | t-test | Coefficient | t-test | Coefficient | t-test | Coefficient | t-test *(a)* | Coefficient | t-test *(a)* |
| **Production function** | | | | | | | | | | |
| Constant | -0.553 | -0.36 | 0.257 | 1.77 | -0.495 | -0.35 | -0.419 | -0.27 | 0.595 | 3.91 |
| LAM | 0.110 | 1.36 | | | 0.003 | 0.00 | 0.005 | 0.07 | | |
| LWCM | 0.397 | 5.65 | 0.382 | 5.76 | 0.430 | 5.60 | 0.416 | 5.12 | 0.416 | 5.52 |
| LTAM | 0.304 | 2.25 | 0.250 | 2.44 | 0.270 | 2.36 | 0.255 | 2.16 | 0.238 | 2.54 |
| LAVM | 0.416 | 4.52 | 0.347 | 4.44 | 0.427 | 5.18 | 0.439 | 5.20 | 0.451 | 5.69 |
| DCROP*LAM | 0.068 | 0.95 | | | 0.008 | 0.12 | -0.010 | -0.14 | | |
| DCROP*LWCM | 0.118 | 1.96 | 0.136 | 2.24 | 0.095 | 1.36 | 0.114 | 1.58 | 0.107 | 1.51 |
| DCROP*LTAM | -0.059 | -0.54 | -0.026 | -0.24 | -0.035 | -0.33 | -0.048 | -0.45 | 0.012 | 0.11 |
| DCROP*LAVM | 0.039 | 0.52 | 0.049 | 0.69 | 0.002 | 0.02 | 0.013 | 0.16 | 0.007 | 0.09 |
| DLIVE*LAM | 0.101 | 1.28 | | | 0.051 | 0.70 | 0.066 | 0.92 | | |
| DLIVE*LWCM | -0.212 | -2.86 | -0.175 | -2.55 | -0.237 | -3.26 | -0.236 | -3.27 | -0.222 | -3.09 |
| DLIVE*LTAM | -0.243 | -2.08 | -0.195 | -1.94 | -0.160 | -1.49 | -0.154 | -1.44 | -0.123 | -1.28 |
| DLIVE*LAVM | 0.204 | 2.03 | 0.230 | 2.80 | 0.207 | 2.25 | 0.201 | 2.21 | 0.227 | 3.09 |
| DLIVE | -0.234 | -1.69 | -0.183 | -1.66 | -0.381 | -2.55 | -0.372 | -2.51 | -0.384 | -2.78 |
| DCROP | 0.640 | 5.66 | 0.632 | 6.13 | 0.525 | 4.52 | 0.516 | 4.11 | 0.532 | 5.68 |
| DAV | 0.877 | 0.57 | | | 1.077 | 0.76 | 1.029 | 0.67 | | |
| .5*LAM^2 | -0.017 | -0.46 | | | 0.004 | 0.09 | 0.005 | 0.11 | | |
| .5*LWCM^2 | -0.128 | -3.69 | -0.104 | -3.01 | -0.133 | -3.37 | -0.149 | -3.64 | -0.137 | -3.75 |
| .5*LTAM^2 | -0.172 | -2.22 | -0.193 | -2.34 | -0.127 | -1.47 | -0.152 | -1.87 | -0.167 | -1.93 |
| .5*LAVM^2 | 0.080 | 1.33 | 0.063 | 3.32 | 0.075 | 1.40 | 0.076 | 1.33 | 0.049 | 2.29 |
| LAM*LWCM | 0.035 | 1.24 | | | 0.040 | 1.60 | 0.044 | 1.70 | | |
| LAM*LTAM | 0.077 | 1.45 | | | 0.085 | 1.77 | 0.095 | 2.02 | | |
| LAM*LAVM | -0.077 | -1.90 | | | -0.075 | -1.93 | -0.078 | -1.95 | | |
| LWCM*LTAM | 0.113 | 2.30 | 0.111 | 2.32 | 0.116 | 2.30 | 0.108 | 2.18 | 0.137 | 3.44 |
| LWCM*LAVM | 0.061 | 2.25 | 0.030 | 1.08 | 0.068 | 2.48 | 0.074 | 2.72 | 0.068 | 2.59 |
| LTAM*LAVM | -0.088 | -1.73 | -0.046 | -0.78 | -0.125 | -3.49 | -0.120 | -3.07 | -0.087 | -2.41 |
| **Control variables** | | | | | | | | | | |
| PIA | 0.349 | 2.36 | 0.276 | 2.25 | 0.264 | 1.59 | 0.292 | 1.73 | 0.240 | 1.69 |
| PIA*LAM | 0.230 | 2.27 | | | 0.180 | 1.83 | 0.192 | 1.89 | | |
| PIA*LWCM | 0.128 | 1.72 | 0.184 | 2.80 | 0.165 | 2.05 | 0.176 | 2.19 | 0.229 | 2.99 |
| PIA*LTAM | -0.033 | -0.27 | | | 0.004 | 0.03 | 0.033 | 0.28 | | |
| PIA*LAVM | -0.240 | -2.92 | -0.083 | -1.25 | -0.269 | -3.20 | -0.278 | -3.26 | -0.148 | -2.39 |
| DL4 | -0.317 | -3.25 | -0.262 | -2.78 | -0.285 | -3.16 | -0.274 | -2.93 | -0.231 | -2.51 |
| DL5 | -0.397 | -3.73 | -0.356 | -3.57 | -0.416 | -4.04 | -0.410 | -3.88 | -0.388 | -4.04 |
| ln{\sigma_v} | -0.865 | -17.0 | -0.838 | -15.5 | -1.020 | -14.12 | -1.026 | -12.31 | -1.027 | -11.3 |
| **Innefficiency effect** | | | | | | | | | | |
| Constant | 2.518 | 3.21 | 1.678 | 3.87 | 0.121 | 0.28 | -0.302 | -0.55 | -0.334 | -0.66 |
| LAM | -0.069 | -0.42 | | | 0.150 | 1.55 | 0.151 | 1.57 | | |
| LWCM | 0.486 | 3.05 | 0.464 | 4.05 | 0.216 | 1.83 | 0.196 | 1.67 | 0.223 | 2.17 |
| LTAM | 0.847 | 2.62 | 0.753 | 2.63 | 0.974 | 4.81 | 0.793 | 4.40 | 0.771 | 4.39 |
| LAVM | 0.159 | 1.60 | | | 0.166 | 2.00 | 0.156 | 1.60 | 0.208 | 2.17 |
| DMANAG | -0.350 | -1.72 | | | -0.418 | -2.85 | -0.394 | -2.60 | -0.362 | -2.39 |
| DEX | 0.369 | 0.97 | | | 0.544 | 3.36 | 0.556 | 2.81 | 0.474 | 3.01 |
| FS | -0.184 | -3.07 | -0.128 | -1.98 | -0.294 | -5.55 | -0.254 | -4.55 | -0.244 | -5.34 |
| AGE | -0.007 | -0.99 | | | 0.013 | 2.03 | 0.015 | 2.63 | 0.014 | 2.64 |
| EDU | -0.020 | -1.11 | | | -0.024 | -2.24 | -0.024 | -2.43 | -0.022 | -2.60 |
| SHA | -4.582 | -5.13 | -4.498 | -6.58 | -2.333 | -7.11 | -1.507 | -4.04 | -1.438 | -3.93 |
| DLIVE | -0.519 | -1.01 | | | -0.873 | -2.39 | -0.812 | -2.50 | -0.769 | -2.87 |
| DCROP | 0.541 | 1.66 | 0.545 | 2.26 | 0.026 | 0.17 | -0.094 | -0.41 | | |
| DINDAP | 0.052 | 0.21 | | | 0.148 | 1.06 | 0.089 | 0.16 | | |
| POA | 0.167 | 0.59 | | | -0.059 | -0.35 | -0.160 | -1.06 | | |
| ACC | 0.028 | 0.65 | | | -0.011 | -0.54 | -0.019 | -1.04 | | |
| CRED | -0.008 | -0.07 | -0.068 | -0.67 | -0.023 | -0.39 | -0.009 | -0.15 | | |
| DOFF | 0.522 | 2.49 | 0.543 | 2.47 | 2.213 | 4.61 | | | | |
| **Genegered Regressors** | | | | | | | | | | |
| Probit Residuals (Doff) (b) | | | | | -3.043 | -5.37 | | | | |
| Fitted Values Doff from Probit (Doff) (c) | | | | | | | 2.196 | 5.01 | 2.063 | 5.34 |
| L = log-likelihood | -240.7 | | -251.7 | | -223.2 | | -232.9 | | -240.6 | |
| Number of parameters | 52 | | 32 | | 53 | | 52 | | 36 | |
| **Mean Efficiency** | **0.85** | | **0.84** | | **0.76** | | **0.73** | | **0.72** | |
| **Testing** | | | | | | | | | | |
| LR test | | | 21.9 | | 34.9 | | | | 15.62 | |
| Number of restrictions (m) | | | 24 | | 1 | | | | 16 | |
| Chi-square (m, 0.95) | | | 36.41 | | 3.84 | | | | 26.29 | |
| Decision | | | No rejected<br>(2) is better than (1) | | Rejected<br>(3) is better than (1) | | | | No rejected<br>(5) is better than (4) | |

*(a)* The t-test are not corrected
*(b)* The residuals are from the probit considering all the instruments both for the variable credit and for the variable participation
*(c)* The fitted values are getting from the estimated Probit model

Source: Own calculations using survey data

## Table 33
## Likelihood ratio tests for production frontier models of non-specialized producers

| *Null hiphotesis* | *Best Model without taking account endogeneity* | | | *Best Model taking account endogeneity* | | |
|---|---|---|---|---|---|---|
| | *Cobb Dougles (a)* (1) | *No technical effects (b)* (2) | *No ineffciency (c)* (3) | *Cobb Dougles (a)* (4) | *No technical effects (b)* (5) | *No ineffciency (c)* (6) |
| *LLF* | *-262.697* | *-284.562* | *-291.65* | *-252.46* | *-286.16* | *-290.38* |
| *Number of paremeters* | *26* | *25* | *24* | *30* | *25* | *23* |
| *Number of restrictions* | *6* | *7* | *8* | *6* | *11* | *12* |
| *Critical Value* | *12.59* | *14.06* | *14.85** | *12.59* | *19.67* | *20.41** |
| *LR* | *21.94* | *65.68* | *77.32* | *23.64* | *91.06* | *99.50* |
| *Decision* | *Rejected* | *Rejected* | *Rejected* | *Rejected* | *Rejected* | *Rejected* |

(a) All cross effect terms = 0; (b) all $\square_j$ = 0, and (c) $\square_0$ and all $\square_j$ = 0

* The test involves inequality and equality restrictions, and Koddle and Palm (1986) provide upper and lower bounds to evaluate its significance.

Source: Own calculations using survey data

## Table 34
## Estimation of partial production elasticities for production frontier model of non-specialized producers

| Elasticities | Irrigation | MIX producers | | Crop Oriented Producers | | Livestock oriented Producers | |
|---|---|---|---|---|---|---|---|
| | | Without endogeneity (1) | With endogeneity (2) | Without endogeneity (3) | With endogeneity (4) | Without endogeneity (5) | With endogeneity (6) |
| **Working Capital** | Without | 0.38 | 0.42 | 0.52 | 0.42 | 0.21 | 0.19 |
| | With | 0.42 | 0.47 | 0.57 | 0.48 | 0.23 | 0.22 |
| **Labor** | Without | 0.25 | 0.23 | 0.25 | 0.23 | 0.06 | 0.23 |
| | With | 0.25 | 0.23 | 0.25 | 0.23 | 0.06 | 0.23 |
| **Capital Stock** | Without | 0.35 | 0.45 | 0.35 | 0.45 | 0.58 | 0.68 |
| | With | 0.35 | 0.42 | 0.35 | 0.41 | 0.58 | 0.66 |

Source: Own calculations using survey data

The mean efficiency in the sample is 84% (at the bottom of Column 2 in **Table 32**) and only a few variables explain the variance of the inefficiency from a statistical point of view. It is important to keep in mind that the variables that explain the variance of the inefficiency explain the mean inefficiency, so that a negative sign indicates a contribution to technical efficiency and vice-verse. Note that we can directly interpret the parameters of the variables in the inefficiency model as their marginal effects because we have used the scaling property to model the inefficiency

The results indicate that there is a positive relation between efficiency and family size (FS) and share of on-farm income on the total income (SHA). Additionally, technical efficiency decreases with increasing use of the inputs working capital (LWCM) and labor (LTAM), if the farmer is crop-oriented (DCROP), and if household participates in off-farm activities (DOFF). On the other hand, among the variables not significant in the estimation, contrary to expectation, are the used land (LAM), credit (CRED) and participation in INDAP (DINDAP)[46].

[46] As in the previous chapter, two dummies were separately incorporated in the estimations, but none of them was significant. One of the dummies takes the value of 1 if any household member participates in some INDAP program and the other dummy takes the value 1 if any household member received or had received credit in the last years.

In line with the procedure suggested by Davidson and MacKinnon (1993), Column 3 of **Table 32** shows the estimation that incorporates two new regressors, the residuals of the estimations Tobit and Probit[47]. Based on the LR test (the last row in Column 3), it is possible to prove that this specification is better than the specification of Column 1. In other words, there is statistical evidence to only support the hypothesis of endogeneity of the variable participation in off-farm activities (DOFF). Then, we proceeded to incorporate the fitted values of the estimation Probit in place of the variable participation in off-farm activities and estimate a new specification, which we call full model and showed in the Column 4 of **Table 32**. The results of this estimation confirm that the parameter of the pseudo-instrument remains significant and with the previous sign; however, it is possible to notice some differences in the parameters of both the underlying technology and of the inefficiency model.

Using the LR test, the best model, which takes into account the endogeneity of the participation in off-farm activities, is presented in Column 5 of **Table 32**. The analysis of the results is similar to that previously done, in terms of describing the technology, the role of the control variables over the technology, and the variables that explain the variance of the inefficiency.

In the best model, again, the proxies of intermediate inputs, capital and labor are the variables that statistically explain the production under a translog production function, rejecting a specification Cobb Douglas (**Table 33**, Column 4). The variable used land (LAM) was not significant in any estimation either individually their interactions. Moreover, the analysis of the regularity conditions shows that the technology satisfies monotonicity[48] and quasi-concavity. In addition, the hypothesis of constant return to scale at sample mean was not possible to reject, and the technology would be homothetic (**Table 35**)[49].

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47 Estimations of the Probit and Tobit models are presented in **Appendix 5**. Those are reduced form estimations which mean that each one takes as explanatory variables all the variables of the original model plus the instruments of both the variable credit and of the variable participation in off-farm activities. The Tobit estimation shows a *R-square* of 0.44 and the Probit estimation correctly predict the 70% of the total outcomes, and 74% of the decisions of participation.

48 The monotonicity condition is not fulfilled one hundred per cent in the input labor. Of the three groups analyzed, the crop-oriented producers reached the higher percentages with 97% followed by the mix producers (89%) and the livestock-oriented producers (69%). This could be explained by differences in the intensity of the input used in each group. Unfortunately, the estimation of family labor force did not take into account this point (see Chapter IV).

49 **Table 35** does not show the test to check whether the technology is homothetic. The value Chi-square estimated is 5.52 which is smaller than 7.81 ($X^2_{(3,\ 0.95)}$), and, therefore, we can not reject the null hypothesis that the technology is homothetic. Notice that the statistic considers three constraints, one for each input.

**Table 35**
**Regularity conditions of the best model taking into account endogeneity (Column 5 in Table 34)**

| | *Monotonicity* | *Cuasi Concavity* | *Constant Return to Scale* | | |
|---|---|---|---|---|---|
| | | | $X^2$ | $X^2_{(1,0.95)}$ | *Decision* |
| **Crop-oriented producers** | | | 2.84 | 3.84 | **No Rejected** |
| Working capital | 100% | 100% | | | |
| Labor | 97% | | | | |
| Animal market value | 100% | | | | |
| **Livestock-oriented producers** | | | 0.01 | 3.84 | **No Rejected** |
| Working capital | 100% | 100% | | | |
| Labor | 69% | | | | |
| Animal market value | 100% | | | | |
| **Mixed producers** | | | 0.71 | 3.84 | **No Rejected** |
| Working capital | 100% | 100% | | | |
| Labor | 89% | | | | |
| Animal market value | 99% | | | | |

Source: Own calculations using survey data

The partial production elasticities are shown in **Table 34** (Columns 2, 4, and 6), observing some differences with regards to the model without endogeneity, and the control variables maintain their effect on the production except for the variable PIA, which is no longer significant at level of 5%.

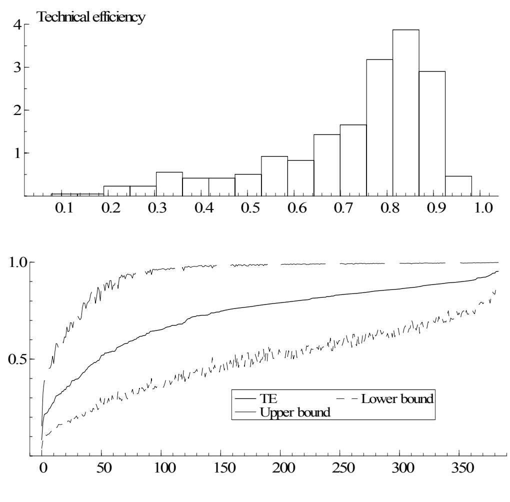
The mean efficiency is 72% (in the bottom of Column 5 in **Table 32**), but now there are more variables that explain the variance of the inefficiency. The tests conducted show that the inefficiency is properly explained by the variables considered and the estimation improves when the variance of the inefficiency term is modeled. Thus, we reject the null hypothesis of no inefficiency because the statistic value is 99.50, which is larger than 20.41 (**Table 33**, Columns 5 and 6).

Effectively, after using projection for the variable participation in of-farm activities based on the estimation Probit (fitted values), more variables are significant. According to the results, the efficiency increases with a family size larger (FS), with more educated family head (EDU), with a higher dependence of the on-farm income (SHA), with efforts for improving his management by spending money on activities that strengthen it (DMANAG), and with a biased production towards livestock activities (DLIVE). Remember that non-specialized farmers have been separated in three groups; mixed producers, crop and livestock-oriented. Additionally, we took the mixed producers as a reference unit in the inefficiency model, which is not significant. The interpretation of the result would be that the non-specialized farmers are more efficient as soon as they are livestock-oriented and there is not evidence to support the diversification. On the other hand, the efficiency decreases when household participates in off-farm activities (DOFF), when the head of family is older (AGE), when there is an increasing use of the inputs working capital (LWCM), labor (LTAM), and capital (LAVM), and when the farmer receives extension services (DEX).

Notice that the variables proxies of DOFF and SHA are measuring two important issues at the same time: First, the impact of the participation of the household in off-farm activities on the technical efficiency by mean of DOFF. Second, the magnitude of this participation on the technical efficiency by mean of SHA, because a higher value of SHA implicitly implies a lower magnitude of participation in off-farm activities.

The preliminary result concerning the impact of extension services on the efficiency is disappointing because it would be suggesting that the efforts of extension have not produced the effects expected and, on the contrary, have gone in the opposite direction, which could be explained by a bad quality of the service and/or an inadequate implementation[50]. Finally, the distribution of inefficiency is biased to farms with scores between 0.7 and 0.9 and the confidence intervals are quite wide for farmers, in particular, for less efficient farmers (**Figure 8**).

**Figure 8**
**Distribution of efficiency and confidence intervals for non-specialized producers**




Source: Own calculations using survey data

50 In the sample 26% of farmers had extension service, which was basically financed by INDAP. Additionally, there is some evidence that suggest that the extension program has increased the productivity but with increasing costs (Lopez, 1996). However, our finding should be taken with caution because we are indeed measuring the efficiency on the value of total production and not on the physical amount of output.

# Chapter VII

# Credit and Production: A Micro-econometric Study of Small Farmers

## 7.1 Introduction

Many people believe that agricultural development strongly depends on credit, and there are much research about that both theoretical and empirical. In fact, the literature has basically analyzed the role of credit on adoption (Feder *et al.*, 1985; Zeller *et al.*, 1998; and Simtowe and Zeller, 2006), investment (Feder *et al.*, 1992 and Foltz, 2004), efficiency (Saldias, Chapter V and VI), living conditions (Pitt *et al.*, 1999; Mckernan, 2002; Pitt and Khandker, 2002; and Khandker and Faruqee, 2003) and agricultural production (Feder, 1990 and Carter, 1989). In addition, since the seminal works of Stiglitz and Weiss (1981) and De Meza and Webb (1987), abundant literature has focused on the nature and consequences of credit rationing in markets with imperfect information. At the agricultural sector level, Carter (1988), Bell *et al.* (1997), Park *et al.* (2002), and Kochar (1997) have contributed to the understanding of the equilibrium of the rural credit markets with rationing.

The asymmetries of information have been incorporated in the decision-making processes, the design of the contracts (lender and borrower), and the equilibrium conditions of the markets (Barry and Robinson, 2001; Conning and Udry, 2007; Ines, 1990; Janda, 1994; Natarajan, 2004; and De Janvry and Sadoulet, 2006). From a less theoretical perspective, some works have advanced towards a stronger institutional framework that promotes and strengthens the rural finance, in particular, in developing countries (Nagarajan and Meyer, 2005; Zeller, 2003; Zeller and Meyer, 2002; Yaron *et al.*, 1997; and Gonzalez-Vega, 2003).

In general, public policy has worked on the design of new financial instruments, has had active participation in rural credit markets, basically helping small farmers to get credit in more favorable conditions, or directly subsidizing the interest rates of credit, and has been developing institutions ad-hoc in order to foster the development of private institutions that help with financial intermediation. In all of this process, Chile has not been the exception.

The small farmers in Chile account for 278,000 units with an average surface of 14 hectares, accounting for 85% of the total farmers in the country, and more than 40% of crop, cattle and vegetable national production. They are characterized by a high heterogeneity in production, technology and access to financial markets. The financing is mainly based on private sector resources such as the farmer's resources, the capital market (formal and/or informal), funds from agro industry and the export companies. The Chilean government has carried out several initiatives in order to remove the high dependence of the farmers on INDAP, a public institution that promotes the rural development of this kind of farmer by providing credit and subsiding extension services. According to Chapters V and VI, INDAP finances more than 70% of the borrowing in rural Chilean areas.

Quiroz (2002) suggests that the amount of money lent to small farmers is clearly insufficient and the share of agricultural formal credit over total credit lent by financial institutions has clearly decreased in the last ten years, the lack of specialized banks in the sectorial risk analysis being one of the most important problems. Additionally, Quiroz (2002) identifies some problems concerning financial regulation that have not permitted a higher share of the formal credit market. In effect, banks look at the agricultural sector, especially the small and medium farmers, with extreme caution.

Chile does not have studies that evaluate the "impact" of the credit markets on the production of small farmers; however, it is widely believed that increased credit could improve the production of most of small farmers. We want to study this theme from a micro-econometric point of view. Thus, the objective of this chapter is twofold. The first is to test the hypothesis of Liquidity (HL), which was defined in Chapter III as a situation in which the constrained household production depends on the amount of credit, unlike unconstrained households, which do not. Second, based on the literature of Treatment Effects, we want to measure the impact of credit and credit constraints on the production of small farmers in Chile, understanding such an impact as the change in the average production level between a situation with treatment (credit or credit constraint) and a situation without treatment. To do this, we use the technique of the switching regression model to consistently estimate the difference between the parameters of each regime, parameters that will be finally used to measure the impact.

We used a country-wide sample which was divided in three groups according to production profile; crop, livestock and mixed producers. We believe that this issue is very important for the design of public policy interventions in the future because there is currently a high demand of public funds motivated by a wide group of actors (farmers, politicians, policy makers) who are trying to justify these demands as a way of solving the deteriorated situation of Chilean small farmers.

The literature that has studied the impact of the credit on the production has followed two ways. One way is studying a credit market in disequilibrium (Feder *et al.*, 1990), where the credit constraints play an important role in explaining the hypothesis of Liquidity (HL) in constrained households. The other way is studying a credit market in equilibrium (Carter, 1989), where the impact of credit has been estimated. Those studies have used the technique of switching regression models (SRM) which is based on a known sample separation. In the first case, the separation is between constrained and unconstrained farmers, and in the second case the separation is between farmers that received credit and those who did not.

None of the papers reviewed in this line of research have checked two important issues: bivariate normal distribution, which is the base assumption behind such models, and the equality of the parameters among the groups analyzed (functions estimated), which, based on the literature of treatment effects, is basic to measure the impact on production.

This chapter makes three contributions to the empirical literature concerning the relationship between credit and production. First, we checked whether the switching regression models are appropriate in this context by testing the assumption of normality. Second, we estimated the impact of both credit constraints and credit on production by using consistent estimates. Third, we analyzed three Chilean production sectors in order to check for differences in the results.

## 7.2 Model specification and data analysis

### 7.2.1 Model specification

Based on the conceptual framework developed in Sections 3.1.1, and 3.3, Chapter III, Probit and OLS models are defined using a sample of 835 farmers from which 457 are crop producers, 213 livestock producers and 165 mixed producers, accounting for 55%, 26%, and

20% of the total sample, respectively[51] (see Chapter IV for a more detailed explanation).

The independent variables used in the estimation of the Probit models both for credit constraint (DCC) and credit (DCRED) have been chosen according to the literature reviewed. We have used proxies of wealth, collateral, social capital, lender perception, and signaling from the farmers. However, it is important to keep in mind that the effects expected of such variables are the result of the *interaction between demand and supply* so that for some variables we can not define them in advance. This is valid for both conditions (credit constraint and credit); however, modeling the condition of credit constraint is more difficult because this is the result of demand surplus in the credit market.

In **Table 36,** we define the variables used for each Probit model[52]. Each model used almost the same variables; however, the credit constraint model used three additional variables; the proportion of own land (POA), the dummy variables DMANAG and DCRED. On the other hand, the model that explains credit uses two extra variables; the dummy variable DINDAP, which takes the value 1 if the household received any support from INDAP and the variable DINDTYPE, which measures the historical payment behavior of farmers, taking the values 1, 2, and 3, with 3 being the worst classification.

In this Chapter we use a Cobb-Douglas technology to explain the production value instead of another more flexible one because we are focusing on the impact of both credit constraint and credit on the production more than the technological parameters of the production function[53].

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[51] Notice that the crop producers are composed of 342 specialized crop farmers with a Herfindahl index equals to 1 and 115 crop-oriented farmers with a Herfindahl index lower than 1. Moreover, the livestock producers are composed of 109 specialized livestock farmers (Herfindahl index equals to 1) and 104 livestock-oriented farmers (Herfindahl index lower than 1) (**see Table 12**).

[52] A more detailed explanation is found in Chapter IV. Additionally, notice that the justification and use of the Probit formulation used in this chapter are different from those used in Chapters V and VI. In those chapters the Probit models were used to estimate a linear projection of the endogenous variables, which was obtained using not only the instruments, but also all the exogenous variables used in the model.

[53] According to the results found in Chapters V and VI, we are aware that more flexible technologies could adjust better to the available sample. However, it is important to keep in mind that the objectives of Chapters V and VI were to estimate and to explain technical efficiency. In contrast, this chapter, from a theoretical point of view, deals with estimations of reduced-form equations instead of structural equations, at least in the estimations used to test the hypothesis of liquidity (HL), which makes it difficult to define in advance a particular parametrization for the equations to be estimated. On the other hand, from a practical perspective and given that our motivation is to get a general idea about the impact of credit and credit constraints on the average production, estimating translog production functions would increase the number of parameters in the model, which, given the availability of information and the nature of the model, would loss us more degrees of freedom in the estimations.

**Table 36**
**Specification of Probit models**

| | | | Credit constraint | Credit |
|---|---|---|---|---|
| Dependent variable | DCC | 1 if household is constrained | | |
| | DCRED | 1 if household receives credit | | |
| Independent variables | LA | Used land | ✓ | ✓ |
| | LAV | Market value of livestock evaluated at average prices of the sample | ✓ | ✓ |
| | PIA | Proportion of irrigated land | ✓ | ✓ |
| | DL3 | 1 if household is located in macro zone 3 | ✓ | ✓ |
| | DL4 | 1 if household is located in macro zone 4 | ✓ | ✓ |
| | DL5 | 1 if household is located in macro zone 5 | ✓ | ✓ |
| | EDU | Years of schooling of the head of family | ✓ | ✓ |
| | AGE | Age of the head of family | ✓ | ✓ |
| | DSEX | 1 if the head of family is male | ✓ | ✓ |
| | SHA | Share of the on-farm income in total income | ✓ | ✓ |
| | ACC | Kms. to get to the main road | ✓ | ✓ |
| | FS | Family size | ✓ | ✓ |
| | CS | Credit scoring | ✓ | ✓ |
| | DOPR | 1 if some household's member belongs to an organization | ✓ | ✓ |
| | INDEX | Value of the Herfindahl index | ✓ | ✓ |
| | LTI | Total income | ✓ | ✓ |
| | NDEPEND | Number of dependents (Children and old people) | ✓ | ✓ |
| | DEPEND | Ratio of children plus older people to family size | ✓ | ✓ |
| | TST | Total household's years of schooling | ✓ | ✓ |
| | DMANAG | 1 if a farmer spends some money on management during the year | ✓ | |
| | POA | Proportion of own land | ✓ | |
| | DCRED | 1 if a household receives credit | ✓ | |
| | DINDAP | 1 if a household receives some support from INDAP | | ✓ |
| | DINDTYPE | Historical payment behavior of farmers, taking values 1, 2 and 3 (the worst one) | | ✓ |

L indicates log form
Source: Own definition

The dependent variable is the weighted on-farm total income using as weights the shares of each activity (crop, livestock, fruit and vegetables), and log y is the decimal logarithm of this variable. The independent variables used in the estimation of the production value functions are shown in **Table 37**. In general, the independent variables are classified in four groups; inputs (LA, LWC, LAV, and TA), quality of soil (PIA), localization (DL3, DL4, and DL5), quality of labor force (EDU and AGE), and management of technological risk (DEX), which takes the value 1 if the household receives extension services.

However, to test the hypothesis of liquidity (HL) we estimate a reduced-form supply function, which means that we have to use only variables that are strictly exogenous. Thus, we do not take the variables of working capital (WC) and the dummy variable DEX because they could be constrained to the availability of credit in the short-term. In addition, we used the amount of credit, CRED, and the number of dependents, NDEPEND, according to the model developed in Section 3.1.1, Chapter III. We assume that the variable NDEPEND is positively related to household's consumption decisions. The rest of the functions estimated (credit constraint and credit) use the variables of working capital and extension services, because we assume that they are proxies of intermediate inputs.

**Table 37**
**Specification of variables of the production value functions (*)**

| Variables | Definition | Explanation | Hypothesis of Liquidity | Measuring the impact (Treatment Effect) | |
|---|---|---|---|---|---|
| | | | | Credit constraint | Credit |
| Dependent | LY | On-farm income (thousands of pesos) | ✓ | ✓ | ✓ |
| Independent | LA | Used land (hectares) | ✓ | ✓ | ✓ |
| | LWC | Working capital (thousands of pesos) (**) | | ✓ | ✓ |
| | LTA | Labor force (hours per week) | ✓ | ✓ | ✓ |
| | LAV | Animal market value (thousands of pesos) | ✓ | ✓ | ✓ |
| | PIA | Proportion of irrigated land (%) | ✓ | ✓ | ✓ |
| | DL3 | 1 if household is located in macro zone 3 | ✓ | ✓ | ✓ |
| | DL4 | 1 if household is located in macro zone 4 | ✓ | ✓ | ✓ |
| | DL5 | 1 if household is located in macro zone 5 | ✓ | ✓ | ✓ |
| | EDU | Years of schooling | ✓ | ✓ | ✓ |
| | AGE | Age | ✓ | ✓ | ✓ |
| | DEX | 1 if household has extension services (**) | | ✓ | ✓ |
| | CRED | Amount of credit received (thousands of pesos) | ✓ | | ✓(***) |
| | NDEPEND | Number of dependents | ✓ | | |

(*) The input prices are not available, because the interview did not ask about input prices.
(**) is a variable input constrained to liquidity in the short-term
(***) is a variable that only appears in the equation of production for who received credit.
L indicates log form
Source: Own definition

### 7.2.2 Data analysis

The descriptive statistics of the sub-groups are given in **Table 38**, distinguishing between the conditions of credit constraint and credit. We can say that 30% of livestock producers had credit and 45% were constrained; a quite similar situation was observed in crop and mixed producers with 37% and 40% with credit, and 46% and 45% with credit constraints, respectively. From the results of Chapter V and VI, we can say that for those farmers who get formal credit, it basically comes from INDAP (70%), followed by BancoEstado (20%). Additionally, crop production is basically concentrated in four crops (wheat, maize, potatoes and rice) which accounts for 80% of the used land, and takes place in the country's central area. On the other hand, livestock production is basically composed of cattle, sheep and goats; however, from the animal weight unit point of view, the stock of cattle accounts for 75% of the endowment of livestock, which is mainly localized in the southern zone.

The figures of **Table 38** provide interesting insights about the situation of small farmers in each sector analyzed. For example, in crop production, the on-farm income levels are higher in farmers who have credit in comparison with those who do not; this does not happen between farmers that are constrained and unconstrained. A similar situation is observed in mixed production. On the contrary, there are not differences, from a statistical point of view, between the income levels in livestock production between who have credit (credit constraint) and who do not. On the other hand, when we analyze the levels of the variables used to explain the on-farm income levels, we can say that under the credit constraint condition several inputs are statistically different in crop production, just a few of them in livestock production (A, AGE and DEPEND), and only irrigation (PIA) in mixed production. Additionally, under the condition of credit it is possible to observe that several inputs show differences in each sector, and though there are not differences at the on-farm income level in livestock production, there are differences at the input level.

Those results suggest that the credit constraint condition apparently does not play a role in explaining the differences in the on-farm income levels in the sectors analyzed, but credit does, at least in the sectors of crop and mix production. Effectively, the two groups potentially differ in terms of their observable characteristics, such as endowments of inputs and environmental factors, and unobservable characteristics, such as endowments of farming and entrepreneurial skills.

The issue is to know whether the statistical association between on-farm income and credit (constraint) among the groups analyzed is a consequence of credit (constraint) itself or is only a spurious correlation induced by the fact that farmers receipts (unconstrained) enjoy more favorable endowments of either observable or unobservable characteristics, and would exhibit higher on-farm incomes even without credit (constrained). This type of question will be econometrically tested in the next section.

## Table 38
## Descriptive statistics of the credit market conditions for type of producers

| Variables | CROP | | | | | | LIVESTOCK | | | | | | MIXED | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Credit constraint | | | Credit | | | Credit constraint | | | Credit | | | Credit constraint | | | Credit | | |
| | Unconstrained | Constrained | t-test | Non-credit | Credit | t-test | Unconstrained | Constrained | t-test | Non-credit | Credit | t-test | Unconstrained | Constrained | t-test | Non-credit | Credit | t-test |
| | 248 | 209 | | 286 | 171 | | 116 | 97 | | 149 | 64 | | 91 | 74 | | 99 | 66 | |
| | *Mean* | *Mean* | | *Mean* | *Mean* | | *Mean* | *Mean* | | *Mean* | *Mean* | | *Mean* | *Mean* | | *Mean* | *Mean* | |
| Y | 2696 | 3055 | -0.70 | 1931.9 | 4412.1 | -4.84 | 1021 | 964 | 0.31 | 924 | 1,159 | -1.18 | 983.5 | 1077.6 | -0.45 | 769.8 | 1409.6 | -3.12 |
| TI | 4148 | 4146 | 0.00 | 3216.4 | 5704.3 | -4.36 | 2287 | 2586 | -0.82 | 2,516 | 2,206 | 0.79 | 2266.6 | 3197.3 | -0.88 | 1883.9 | 3884.2 | -1.88 |
| A | 6 | 8 | -1.23 | 4.9 | 10.1 | -4.84 | 29 | 20 | 1.89 | 23 | 30 | -1.47 | 21.6 | 16.5 | 1.35 | 15.8 | 24.5 | -2.32 |
| TA | 90 | 100 | -2.12 | 92.4 | 98.0 | -1.24 | 81 | 84 | -0.45 | 79 | 91 | -1.96 | 88.6 | 89.3 | -0.10 | 88.7 | 89.2 | -0.08 |
| WC | 1957 | 2183 | -0.58 | 1342.4 | 3261.2 | -4.89 | 1770 | 1298 | 1.37 | 1,319 | 2,105 | -2.11 | 1002.5 | 2031.5 | -1.32 | 698.6 | 2612.1 | -2.46 |
| AV | 479 | 710 | -2.08 | 426.9 | 849.1 | -3.74 | 2696 | 2400 | 1.01 | 2,238 | 3,312 | -3.46 | 1860.2 | 1789.6 | 0.24 | 1418.0 | 2444.5 | -3.51 |
| PIA | 0.54 | 0.60 | -1.30 | 0.56 | 0.59 | -0.60 | 0.15 | 0.17 | -0.39 | 0.19 | 0.08 | 2.21 | 0.14 | 0.32 | -3.15 | 0.25 | 0.18 | 1.09 |
| DL2 | 0.20 | 0.20 | 0.04 | 0.22 | 0.16 | 1.62 | 0.11 | 0.06 | 1.28 | 0.11 | 0.03 | 1.95 | 0.02 | 0.03 | -0.21 | 0.03 | 0.02 | 0.62 |
| DL3 | 0.44 | 0.36 | 1.84 | 0.41 | 0.40 | 0.04 | 0.02 | 0.05 | -1.40 | 0.04 | 0.02 | 0.92 | 0.02 | 0.05 | -1.09 | 0.05 | 0.02 | 1.19 |
| DL4 | 0.25 | 0.25 | -0.09 | 0.25 | 0.26 | -0.22 | 0.24 | 0.22 | 0.43 | 0.26 | 0.16 | 1.68 | 0.34 | 0.42 | -1.03 | 0.38 | 0.36 | 0.26 |
| DL5 | 0.11 | 0.19 | -2.50 | 0.13 | 0.18 | -1.62 | 0.63 | 0.67 | -0.62 | 0.58 | 0.80 | -3.03 | 0.62 | 0.50 | 1.49 | 0.54 | 0.61 | -0.89 |
| DEX | 0.15 | 0.25 | -2.69 | 0.12 | 0.34 | -6.01 | 0.23 | 0.26 | -0.42 | 0.17 | 0.42 | -4.09 | 0.22 | 0.20 | 0.27 | 0.14 | 0.32 | -2.77 |
| AGE | 53.87 | 49.91 | 3.00 | 52.98 | 50.52 | 1.80 | 55.78 | 51.48 | 2.42 | 53.36 | 54.92 | -0.80 | 55.41 | 52.05 | 1.51 | 54.38 | 53.18 | 0.53 |
| EDU | 7.58 | 7.63 | -0.10 | 7.85 | 7.19 | 1.23 | 7.39 | 7.27 | 0.19 | 7.17 | 7.72 | -0.79 | 8.02 | 7.76 | 0.27 | 7.39 | 8.67 | -1.28 |
| CRED | 448.5 | 421.0 | 0.19 | 0.00 | 1165 | -8.20 | 127 | 215 | -1.50 | 0.0 | 556 | -10.77 | 119 | 199 | -1.31 | 0.00 | 388 | -7.14 |
| NDEPEND | 1.4 | 1.6 | -1.61 | 1.57 | 1.42 | 1.37 | 1.4 | 1.4 | -0.23 | 1.4 | 1.5 | -0.81 | 1.58 | 1.55 | 0.15 | 1.55 | 1.61 | -0.32 |
| TST | 25.9 | 28.2 | -1.46 | 26.93 | 26.96 | -0.02 | 23.3 | 23.4 | -0.08 | 22.8 | 24.6 | -0.82 | 26.07 | 25.58 | 0.17 | 23.71 | 29.06 | -1.92 |
| DEPEND | 0.4 | 0.4 | 1.37 | 0.39 | 0.34 | 2.04 | 0.5 | 0.4 | 1.77 | 0.4 | 0.4 | 0.50 | 0.44 | 0.39 | 1.06 | 0.42 | 0.42 | 0.08 |
| FS | 3.7 | 4.3 | -3.99 | 3.95 | 3.99 | -0.27 | 3.3 | 3.6 | -1.46 | 3.4 | 3.6 | -0.84 | 3.65 | 3.85 | -0.73 | 3.63 | 3.91 | -1.00 |

Source: Own calculations using survey data

## 7.3 Estimations and discussion

### 7.3.1 Testing joint normality

We checked the assumption of bivariate normality based on the test suggested by Vella and Pagan (1989). Following expression (13) in Section 3.3.3, Chapter III, Columns (1), (2), and (3) in **Table 39** contain the absolute values of the t-statistics for the null hypothesis that the coefficient is equal to zero in the estimations based on the two-stage method. They suggest testing if the variables added to the second-stage estimator in the two-step estimation procedure are jointly zero. Thus, Column (4) shows the Chi-squared value for the null hypothesis that the parameters corresponding to Columns (1), (2), and (3) are jointly zero.

The results show that we could not reject the hypothesis of bivariate normality in the estimations at the 5% significance level, except for the case of crop production, which suggests us that the results found in this sector are not plausible. Effectively, in crop production the Chi-squared tests are higher than 7.8 (critical value) for the cases of constrained farmers and farmers with credit.

**Table 39**
**Results of the joint normality test in switching regression models**

| Sector | Condition | Groups | $(\gamma_i' z_j)^1 \times W$ t-test (1) | $(\gamma_i' z_j)^2 \times W$ t-test (2) | $(\gamma_i' z_j)^3 \times W$ t-test (3) | $\chi^2_{(3,0.95)}$ (4) |
|---|---|---|---|---|---|---|
| Crop | *Credit Constraint* | Constrained | *-0.07* | *-0.31* | *0.28* | *14.30* |
| | | Non-constrained | *0.81* | *-0.52* | *0.42* | *1.20* |
| | *Credit* | With credit | *0.04* | *0.40* | *0.25* | *9.97* |
| | | Without credit | *0.81* | *-1.52* | *1.08* | *3.50* |
| Livestock | *Credit Constraint* | Constrained | *0.64* | *0.83* | *0.55* | *2.04* |
| | | Non-constrained | *-0.12* | *-0.42* | *0.11* | *2.08* |
| | *Credit* | With credit | *0.59* | *0.27* | *-0.12* | *4.77* |
| | | Without credit | *-1.08* | *-0.28* | *-0.31* | *3.67* |
| Mix | *Credit Constraint* | Constrained | *0.35* | *0.38* | *0.38* | *0.15* |
| | | Non-constrained | *-0.54* | *0.17* | *-0.10* | *1.29* |
| | *Credit* | With credit | *-0.73* | *-0.04* | *0.18* | *1.57* |
| | | Without credit | *-0.04* | *-1.75* | *1.46* | *4.04* |

Source: Own calculation using survey data

### 7.3.2 Testing the Hypothesis of Liquidity (HL)

The hypothesis of liquidity (HL) was checked estimating an endogenous switching regression model using Full Information Maximum Likelihood (FIML)[54]. The results are shown in **Table 40**, which indicate that the Probit models estimated correctly predict the outcomes in more than 64% of the cases in the sample with predictions over 70% for the unconstrained farmers. Given our objective in this part of this chapter, we focus only on the parameters of the variables credit (CRED) and number of dependents (NDEPEND). Thus, according to the significance of their parameters, we can say that there is not evidence of HL in the three groups analyzed. Effectively, the parameter of the variable credit was not significant in the constrained farmers, except in the group of crop production, which was significant only at the 10% level. Additionally, the credit was significant for the unconstrained group in crop production, which is contrary to the predictions of the model developed in Section 3.3.1, Chapter III. On the other hand, the variable number of dependents that is related to consumption factors was not significant in the constrained group.

In order to contrast our results, we present in **Appendix 6** the switching regression results using the two-step estimation method (Heckman's procedure). They partially support the hypothesis of liquidity; however, the parameters estimated are less efficient than the estimates with FIML. This can suggest that the results of other studies, which were presented in Table 6 in Chapter IV, could not be valid if they used FIML instead of Heckman's procedure. Further, we want to point out that some differences in the parameters of the Probit model were detected when the selection equation was jointly estimated with the production value functions (FIML).

We claim that the results found could be indicating that the classification of the farmers between constrained and unconstrained was wrong or that the theoretical model developed was wrong. In any case, they should be only interpreted as preliminary evidence. However, we are aware that the classification of constrained and unconstrained farmers is always a difficult issue, in particular in developing countries.

[54] The estimations were conducted with LIMDEP 7.0, and confidence intervals of 95% were built for the *t* and *Chi-squared* tests.

## Table 40
**Testing hypothesis of liquidity using Full Information Maximum Likelihood by sector**

| Variables | CROP | | LIVESTOCK | | MIX | |
|---|---|---|---|---|---|---|
| | *Coeff.* | *t-ratio* | *Coeff.* | *t-ratio* | *Coeff.* | *t-ratio* |
| ***Probit Selection Equation*** | | | | | | |
| CONSTANT | -5.96733 | -2.26 | 2.799710 | 1.30 | 0.30130 | 0.05 |
| LA | -0.85660 | -1.87 | 0.276990 | 0.90 | -0.12667 | -0.09 |
| LAV | 0.12417 | 1.25 | 1.670770 | 2.68 | -1.85674 | -2.63 |
| PIA | 0.15638 | 0.34 | 0.780064 | 1.24 | 0.76883 | 0.53 |
| DL3 | -0.17578 | -0.57 | 1.734570 | 1.80 | -1.17888 | -0.39 |
| DL4 | 0.66654 | 1.32 | 0.849554 | 1.68 | -0.38831 | -0.16 |
| DL5 | 0.77740 | 1.30 | 1.207490 | 2.55 | -0.07628 | -0.03 |
| DMANAG | 0.03548 | 0.20 | 0.085734 | 0.29 | 0.17404 | 0.13 |
| DCRED | -0.18757 | -0.83 | -0.119546 | -0.42 | 0.14829 | 0.11 |
| SHA | 1.37068 | 1.88 | -2.490800 | -4.27 | 2.09856 | 1.75 |
| ACC | 0.00342 | 0.07 | -0.003375 | -0.10 | 0.02576 | 0.43 |
| AGE | -0.00669 | -0.65 | -0.012795 | -1.08 | 0.00138 | 0.02 |
| EDU | -0.00341 | -0.14 | -0.021421 | -0.73 | -0.00259 | -0.03 |
| FS | 0.05532 | 0.63 | -0.080393 | -0.83 | -0.06986 | -0.15 |
| DOPR | 0.26025 | 0.88 | 0.135287 | 0.56 | 0.16678 | 0.23 |
| POA | -0.11836 | -0.56 | -0.102083 | -0.36 | -0.05095 | -0.05 |
| CS | 0.12424 | 0.56 | -0.144623 | -0.47 | 0.24301 | 0.22 |
| INDEX | 0.27615 | 0.23 | 0.074149 | 0.10 | -6.96758 | -1.04 |
| LTI | 1.35942 | 2.23 | -2.397470 | -5.23 | 2.37401 | 1.50 |
| DEPEND | -0.07807 | -0.19 | 0.093833 | 0.17 | 0.02765 | 0.01 |
| TST | -0.00310 | -0.38 | 0.008658 | 0.99 | -0.00358 | -0.08 |
| DSEX | -0.05178 | -0.18 | 0.309991 | 0.75 | 0.17192 | 0.24 |
| ***Constrained Regression Equation*** | | | | | | |
| CONSTANT | 2.93148 | 7.32 | -0.468936 | -1.08 | 0.86070 | 1.13 |
| LA | 0.62518 | 7.40 | 0.170239 | 2.93 | 0.05074 | 0.44 |
| LT | 0.13261 | 0.88 | 0.084930 | 0.82 | 0.02610 | 0.13 |
| LAV | -0.04806 | -1.48 | 0.752493 | 7.48 | 0.65673 | 5.04 |
| PIA | 0.03931 | 0.32 | 0.132746 | 0.95 | -0.06681 | -0.60 |
| DL3 | 0.06280 | 0.57 | 0.236418 | 1.41 | 0.42689 | 0.81 |
| DL4 | -0.40347 | -2.99 | 0.277116 | 2.21 | 0.06854 | 0.14 |
| DL5 | -0.44501 | -2.40 | 0.226528 | 1.44 | -0.07168 | -0.15 |
| EDU | 0.00531 | 0.69 | 0.004753 | 0.46 | 0.00536 | 0.66 |
| AGE | 0.00277 | 0.91 | 0.001312 | 0.54 | -0.00198 | -0.61 |
| ***CRED*** | *0.00008* | ***1.69*** | *0.000029* | ***0.49*** | *0.00007* | ***0.29*** |
| ***NDEPEND*** | *-0.02693* | ***-0.77*** | *-0.035739* | ***-1.47*** | *0.05549* | ***1.52*** |
| ***Unconstrained Regression Equation*** | | | | | | |
| CONSTANT | 2.64439 | 8.41 | 0.079369 | 0.13 | 0.01690 | 0.02 |
| LA | 0.65274 | 8.98 | 0.040389 | 0.37 | -0.02745 | -0.17 |
| LT | 0.18440 | 1.29 | 0.004969 | 0.03 | -0.01688 | -0.06 |
| LAV | -0.02999 | -1.11 | 0.775872 | 4.83 | 0.79095 | 6.24 |
| PIA | 0.30211 | 3.24 | 0.372286 | 1.68 | -0.09129 | -0.47 |
| DL3 | -0.18359 | -2.05 | 0.822056 | 3.21 | 0.50640 | 0.81 |
| DL4 | -0.40926 | -3.62 | 0.452588 | 2.31 | 0.20999 | 0.47 |
| DL5 | -0.26144 | -1.91 | 0.611288 | 2.89 | 0.08450 | 0.19 |
| EDU | 0.00455 | 0.90 | -0.002112 | -0.22 | 0.00266 | 0.36 |
| AGE | -0.00454 | -1.81 | -0.004211 | -1.12 | 0.00105 | 0.30 |
| ***CRED*** | *0.00006* | ***3.27*** | *-0.000005* | ***-0.02*** | *-0.00004* | ***-0.24*** |
| ***NDEPEND*** | *0.02512* | ***0.86*** | *-0.004924* | ***-0.11*** | *0.02402* | ***0.64*** |
| ***Variance Estimates*** | | | | | | |
| $\sigma_1$ | 0.39442 | 8.69 | 0.389543 | 9.96 | 0.32839 | 8.19 |
| $\rho_1$ | -0.47918 | -1.81 | -0.995935 | -62.79 | 0.96458 | 5.78 |
| $\sigma_2$ | 0.53389 | 13.93 | 0.251128 | 10.60 | 0.28675 | 8.91 |
| $\rho_2$ | -0.97669 | -166.65 | 0.905702 | 12.76 | -0.94971 | -87.18 |
| **Observations** | 457 | | 213 | | 165 | |
| **LLF** | -400.3 | | -106.1 | | -60.2 | |

Source: Own calculations using survey data

In relation to the last point, Diane *et al.* (2000) and Petrick (2005) provide excellent reviews about measurements of credit rationing, and the literature has advanced in new directions in the classification of rationing, incorporating in the analysis factors related to risk and transaction cost (Boucher, 2002; and Boucher *et al.*, 2005), which are always difficult to define and to measure. The present research collected information about credit constraint by directly asking borrowers whether they would have liked to borrow more at the prevailing interest rate. Thus, if the answer was positive, respondents were classified as constrained[55].

### 7.3.3 Estimating the impact of credit and credit constraint

In this section the expression (14) of Section 3.3.4 will be used to estimate the impact of the conditions of credit and credit constraint on average sectorial production value. To do that, we estimate a switching regression model by a two-step procedure using the entire sample. In the first step, we estimate Probit models, from which, in the second step, we consistently estimate and identify the parameters that are different from statistical point of view between the regimes analyzed.

**Table 41** shows the results of Probit estimations of credit constraint and credit for each sector. The models fit reasonably well, predicting correctly more than 64% of the total outcomes for the case of credit constraint and more than 76% for the case of the models that explain the credit. However, our models predict in a better way the outcomes of unconstrained farmers and farmers with credit with values over 72% and 80%, respectively.

We do not analyze in details those results because our interest is basically to use them to build **Table 43**, which will be later discussed. However, we can say that the variables that explain the conditions of credit constraint and credit in each sector are different, confirming the necessity of studying each sector separately. Thus for example, the credit constraint in crop production is associated with the quality of soil (PIA), the localization (DL3 and DL4), the importance of the on-farm income on total income (SHA), the family size (FS), the

[55] According to Petrick (2005), there are basically two forms to quantitatively measure credit rationing from an interview. The first one would be to directly ask borrowers whether they would have liked to borrow more at the prevailing interest rate. In the case of a positive answer, respondents are classified as credit constrained. This measurement is used in the present work. The second way would be to ask a given respondent about the maximum amount a lender is willing to lend him, which is the *credit limit* of the respondent with regard to this lender. This credit limit measures the borrower's current access to credit, which may be different for different loan sources.

availability of owned land (POA), the signals given for farmers to potential lenders related to cleanliness and order in the farm (CS), and the grade of specialization in the sector (INDEX). On the other hand, receiving credit, for example in livestock production, is basically explained by the head of family's age (AGE), the head the family's education (EDU), the family size (FS), if the household participates in some production association (DOPR), if the farmer is a INDAP beneficiary (DINDAP), and the history payment behavior of farmers (DINDTYPE). Different situations happen in the other sectors, which can be observed directly in the table.

**Table 42** presents OLS estimations corrected for heteroscedasticity[56] for the production value (LY) by sector (crop, livestock and mixed producers) using the entire sample of each group. Thus, we estimate two regressions for each sector where each one takes into account the conditions of credit constraint and credit. We use the expressions (11) and (12) of Section 3.3.2, Chapter III, for defining the regressions. From those estimations, we identified the parameters that are different, from a statistical point of view, between the two regimes for both the observable and the unobservable variables. Additionally, this estimation gives us information about the characteristics of the equation of regime 1, which in our case is related to unconstrained farmers and farmers without credit.

As our interest is to measure the impact on the production value of both the credit constraint and credit, we will not discuss the parameters obtained in the first part of **Table 42**; however, we want to point out that the dummy variable related to extension services (DEX) was not significant in any estimation, which goes in the same direction as the results obtained in Chapters V and VI. Additionally, in the case of unconstrained farmers, the dummy variable related to credit (DCRED) was not significant, which supports the theoretical model developed in Section 3.1.1, Chapter III.

According to the R-squared, the estimations fit quite well with values that fluctuate between 0.71 and 0.79, and the F-tests confirm the formulation of the model. We can also observe that there are few parameters that are different between the two regimes in each sector in both the case of credit constraint and credit, which could be explained by the cross-sectional data used.

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[56] Maddala (1983) and Wooldridge (2003) show that the errors in the second stage are heteroscedastic, and its correction is not easy because we have to consider the variability associated with the estimation of the Probit model parameters in the first stage.

## Table 41
## Probit estimations of credit constraint and credit by sector

| VARIABLES | CREDIT CONSTRAINT | | | | | | CREDIT | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | CROP | | LIVESTOCK | | MIX | | CROP | | LIVESTOCK | | MIX | |
| | Coeff. | t-ratio | Coeff. | t-ratio | Coeff. | t-ratio | Coeff. | t-ratio | Coeff. | t-ratio | Coeff. | t-ratio |
| CONSTANT | -0.592 | -0.62 | 0.589 | 0.34 | 4.571 | 1.82 | -4.136 | -3.86 | -4.848 | -2.43 | -8.546 | -2.60 |
| LA | -0.108 | -0.58 | -0.287 | -1.12 | 0.256 | 0.73 | 0.548 | 2.69 | -0.027 | -0.09 | -0.047 | -0.13 |
| LAV | 0.048 | 0.85 | -0.239 | -0.61 | -0.281 | -0.65 | 0.077 | 1.27 | 0.569 | 1.25 | 0.090 | 0.19 |
| PIA | 0.625 | 3.15 | 0.534 | 1.22 | 1.224 | 2.95 | 0.057 | 0.27 | -0.508 | -0.95 | -0.330 | -0.73 |
| DL3 | -0.036 | -0.20 | 1.953 | 2.63 | 0.556 | 0.58 | -0.185 | -0.91 | -0.251 | -0.25 | -0.945 | -0.66 |
| DL4 | 0.404 | 1.75 | 0.656 | 1.36 | 0.013 | 0.02 | 0.043 | 0.17 | 0.107 | 0.17 | 0.581 | 0.57 |
| DL5 | 0.995 | 3.49 | 1.035 | 1.94 | 0.121 | 0.16 | 0.464 | 1.48 | 0.942 | 1.44 | 0.809 | 0.78 |
| DMANAG | 0.195 | 1.41 | 0.237 | 1.09 | 0.330 | 1.34 | | | | | | |
| DCRED | -0.156 | -1.12 | 0.292 | 1.38 | 0.644 | 2.57 | | | | | | |
| SHA | 0.521 | 2.14 | -0.310 | -0.72 | -0.480 | -1.09 | 0.405 | 1.55 | 0.031 | 0.06 | 1.197 | 2.39 |
| ACC | 0.022 | 1.23 | 0.004 | 0.18 | 0.030 | 0.79 | -0.002 | -0.15 | -0.067 | -1.34 | -0.001 | -0.03 |
| AGE | -0.007 | -1.28 | -0.017 | -1.83 | -0.012 | -1.20 | -0.004 | -0.76 | 0.018 | 1.72 | -0.009 | -0.82 |
| EDU | 0.009 | 0.68 | -0.014 | -0.50 | 0.019 | 0.73 | -0.020 | -1.29 | 0.058 | 1.91 | -0.004 | -0.15 |
| FS | 0.171 | 3.27 | 0.083 | 1.03 | 0.084 | 0.99 | 0.007 | 0.12 | 0.189 | 1.98 | -0.016 | -0.17 |
| DOPR | 0.153 | 0.71 | 0.212 | 0.97 | -0.150 | -0.59 | -0.100 | -0.44 | 0.462 | 1.84 | 0.639 | 2.27 |
| POA | -0.293 | -1.98 | 0.166 | 0.74 | 0.169 | 0.63 | | | | | | |
| CS | 0.230 | 1.67 | -0.192 | -0.95 | 0.291 | 1.06 | -0.136 | -0.88 | 0.230 | 1.02 | -0.132 | -0.41 |
| INDEX | -1.339 | -1.80 | -0.646 | -1.01 | -5.464 | -1.59 | 2.403 | 2.86 | 0.408 | 0.55 | 2.346 | 0.56 |
| LTI | 0.107 | 0.59 | 0.300 | 0.86 | -0.561 | -1.38 | 0.257 | 1.30 | -0.363 | -0.87 | 1.452 | 3.03 |
| DEPEND | -0.277 | -1.01 | -0.229 | -0.59 | -0.045 | -0.10 | -0.478 | -1.60 | -0.409 | -0.85 | 0.173 | 0.34 |
| TST | -0.005 | -0.85 | -0.012 | -1.14 | -0.015 | -1.20 | -0.006 | -0.84 | -0.006 | -0.52 | 0.015 | 1.16 |
| DSEX | 0.067 | 0.36 | 0.176 | 0.69 | 0.109 | 0.42 | -0.121 | -0.57 | -0.162 | -0.54 | -0.258 | -0.87 |
| DINDAP | | | | | | | 1.384 | 7.17 | 1.797 | 5.88 | 1.962 | 5.26 |
| DINDTYPE | | | | | | | 0.033 | 0.44 | -0.408 | -3.42 | -0.210 | -1.72 |
| ***Chi-squared*** | ***70.3*** | | ***30.1*** | | ***31.3*** | | ***159.0*** | | ***76.6*** | | ***72.6*** | |
| ***Probt Fit*** | | | | | | | | | | | | |
| ***Predcited values correctly*** | | | | | | | | | | | | |
| ***Unconstrained*** | ***0.70*** | | ***0.72*** | | ***0.75*** | | | | | | | |
| ***Constrained*** | ***0.57*** | | ***0.61*** | | ***0.53*** | | | | | | | |
| ***Total*** | ***0.64*** | | ***0.67*** | | ***0.65*** | | | | | | | |
| ***With Credit*** | | | | | | | ***0.80*** | | ***0.90*** | | ***0.83*** | |
| ***Without Credit*** | | | | | | | ***0.68*** | | ***0.56*** | | ***0.71*** | |
| ***Total*** | | | | | | | ***0.76*** | | ***0.80*** | | ***0.78*** | |
| ***Observations*** | ***457*** | | ***213*** | | ***165*** | | ***457*** | | ***213*** | | ***165*** | |
| ***% constrained*** | ***46*** | | ***45*** | | ***45*** | | | | | | | |
| ***% with credit*** | | | | | | | ***37*** | | ***30*** | | ***40*** | |

Source: Own calculations using survey data

## Table 42
## OLS Estimations of the Production Value (LY) by sector
## Corrected for Heteroscedasticity

| VARIABLES | CROP | | | | LIVESTOCK | | | | MIX | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | CONSTRAINT | | CREDIT | | CONSTRAINT | | CREDIT | | CONSTRAINT | | CREDIT | |
| | *Coeff.* | *t-ratio* | *Coeff.* | *t-ratio* | *Coeff.* | *t-ratio* | *Coeff.* | *t-ratio* | *Coeff.* | *t-ratio* | *Coeff.* | *t-ratio* |
| **$\beta$'x** | | | | | | | | | | | | |
| ***Constant*** | 0.52488 | 2.10 | 1.07884 | 5.80 | -0.44141 | -1.29 | -0.35464 | -1.53 | 0.75226 | 1.87 | 0.52894 | 1.72 |
| ***LA*** | 0.13186 | 1.26 | 0.25306 | 4.24 | -0.05599 | -0.49 | 0.15651 | 2.18 | 0.03836 | 0.30 | -0.10788 | -1.23 |
| ***LWC*** | 0.63245 | 6.24 | 0.52010 | 8.61 | 0.44698 | 4.66 | 0.29233 | 5.36 | 0.26917 | 2.43 | 0.35852 | 4.84 |
| ***LT*** | 0.11703 | 0.94 | 0.21764 | 2.26 | 0.01942 | 0.13 | 0.15094 | 1.61 | 0.03894 | 0.19 | 0.07477 | 0.57 |
| ***LAV*** | -0.06759 | -1.91 | 0.01119 | 0.56 | 0.53945 | 3.93 | 0.51820 | 6.15 | 0.43136 | 3.02 | 0.32336 | 3.33 |
| ***PIA*** | -0.16727 | -1.39 | 0.12035 | 1.86 | 0.32221 | 1.86 | 0.17712 | 1.39 | 0.55332 | 1.72 | 0.06904 | 0.79 |
| ***DL3*** | -0.25121 | -2.35 | -0.09126 | -1.48 | -0.28106 | -0.50 | 0.13701 | 0.73 | 0.84170 | 2.16 | 0.26688 | 1.67 |
| ***DL4*** | -0.35791 | -2.82 | -0.22539 | -2.84 | -0.17504 | -0.90 | 0.21642 | 1.88 | 0.49831 | 1.47 | 0.00237 | 0.02 |
| ***DL5*** | -0.51942 | -2.77 | -0.23994 | -2.35 | -0.06312 | -0.28 | 0.15413 | 1.21 | 0.39193 | 1.09 | -0.04097 | -0.27 |
| ***EDU*** | -0.00692 | -1.05 | 0.00273 | 0.59 | -0.00649 | -0.69 | -0.00165 | -0.26 | -0.00224 | -0.42 | -0.00190 | -0.45 |
| ***AGE*** | 0.00659 | 2.36 | -0.00138 | -0.85 | 0.00664 | 1.37 | 0.00042 | 0.21 | -0.00358 | -0.93 | 0.00351 | 1.58 |
| ***DEX*** | -0.12725 | -1.05 | -0.09451 | -1.03 | -0.43604 | -3.83 | -0.02719 | -0.32 | 0.11717 | 1.02 | -0.25234 | -2.30 |
| ***DCRED*** | -0.03425 | -0.42 | | | 0.24625 | 1.55 | | | -0.06473 | -0.37 | | |
| **$\eta$ [$s$ Φ]** | | | | | | | | | | | | |
| ***CRED* Φ** | | | *0.00001* | *1.87* | | | *-0.00008* | *-1.26* | | | *-0.00011* | *-1.39* |
| **($\delta$-$\beta$) [$x$ Φ]** | | | | | | | | | | | | |
| ***LA* Φ** | *0.29454* | *1.60* | *-0.02368* | *-0.17* | *0.30251* | *1.35* | *-0.35089* | *-2.07* | *-0.29143* | *-1.00* | *0.07824* | *0.42* |
| ***LWC* Φ** | *-0.10166* | *-0.53* | *0.07235* | *0.60* | *-0.30142* | *-1.47* | *0.09505* | *0.63* | *0.26116* | *1.17* | *0.03966* | *0.23* |
| ***LT* Φ** | *-0.00044* | *0.00* | *-0.05463* | *-0.29* | *0.35625* | *1.16* | *-0.11363* | *-0.38* | *0.43252* | *1.09* | *0.20918* | *0.76* |
| ***LAV* Φ** | *0.10872* | *1.42* | *-0.04350* | *-1.12* | *0.05545* | *0.18* | *0.16921* | *0.64* | *-0.17525* | *-0.61* | *0.10407* | *0.45* |
| ***PIA* Φ** | *0.32009* | *1.33* | *-0.12443* | *-0.89* | *-0.65299* | *-1.96* | *-0.46926* | *-1.16* | *-0.82242* | *-1.56* | *-0.33076* | *-1.76* |
| ***DL3* Φ** | *0.54901* | *2.39* | *0.15294* | *1.04* | *0.58409* | *0.63* | *0.04634* | *0.07* | *-1.14511* | *-1.66* | *-0.01585* | *-0.05* |
| ***DL4* Φ** | *0.29522* | *1.20* | *0.06941* | *0.40* | *0.80160* | *1.78* | *-0.18527* | *-0.37* | *-1.09364* | *-1.73* | *-0.29231* | *-0.89* |
| ***DL5* Φ** | *0.43537* | *1.26* | *-0.04093* | *-0.19* | *0.35162* | *0.66* | *-0.01482* | *-0.03* | *-0.92043* | *-1.37* | *-0.40707* | *-1.30* |
| ***EDU* Φ** | *0.02322* | *1.57* | *0.00890* | *0.71* | *0.01983* | *0.76* | *0.00206* | *0.13* | *0.00338* | *0.30* | *0.00443* | *0.44* |
| ***AGE* Φ** | *-0.00967* | *-1.81* | *0.00557* | *1.46* | *-0.00927* | *-0.96* | *-0.00010* | *-0.02* | *0.00250* | *0.33* | *-0.00643* | *-1.47* |
| ***DEX* Φ** | *0.24044* | *1.10* | *0.16680* | *1.08* | *0.78002* | *3.51* | *-0.09466* | *-0.55* | *-0.19023* | *-0.83* | *0.42757* | *2.32* |
| ***DCRED* Φ** | *0.08664* | *0.54* | | | *-0.60180* | *-1.99* | | | *0.31683* | *0.93* | | |
| **($\rho_1 - \rho_2$) $\phi$** | | | | | | | | | | | | |
| $\phi$ | *1.27955* | *3.50* | *-0.46309* | *-1.59* | *-0.43038* | *-0.69* | *-0.22203* | *-0.98* | *-1.11177* | *-1.70* | *-0.00819* | *-0.04* |
| **R-squared** | **0.79** | | **0.79** | | **0.72** | | **0.71** | | **0.71** | | **0.79** | |
| **F-test** | **65.7** | | **66.8** | | **19.1** | | **17.7** | | **11.6** | | **12.9** | |
| **Wald Test*** (All **$\delta$-$\beta$ = 0**) | **30.85** | | **17.36** | | **26.08** | | **26.62** | | **10.21** | | **26.17** | |
| **Observations** | 457 | | | | 213 | | | | 165 | | | |

* The critical values are 21.02 ($X^2$ [12, 0.95]) for the case of credit constraint and 19.67 ($X^2$ [11, 0.95]) for the condition of receiving credit.
Source: Own calculations using survey data

However, we can see that there are differences in some parameters in both the observable ($x\Phi$ and $s\Phi$) and the unobservable ($\phi$) variables[57]. At crop the production level, the condition of credit constraint only makes differences in the parameters related to localization in macro zone 3 (DL3Φ) and the unobservable factors ($\phi$). On the other hand, receiving credit does not generate any effect both in the observable and in the unobservable factors. Those results are not plausible because we could find evidence in favor of the hypothesis of normality.

In livestock production, the condition of constraint makes differences in the parameters related to quality of soil (PIAΦ), extension services (DEXΦ) and credit (DCREDΦ). Receiving credit makes differences just in the parameter associated with availability of land (LAΦ). On the other hand, the unobservable factors do not play any role in explaining the effect on production. Finally, in mix production the constraint condition did not produce any difference in the parameters of the variables both observable and unobservable. Receiving credit only makes difference in the parameter of the variable extension services (DEXΦ), and the unobservable factors are not important.

With this information and based on expression (14) of Section 3.3.4, Chapter III, we estimated the *impact on the average production* both of credit constraints and credit in each sector. The exercise was to measure the differential in the levels of expected production values both of the constrained farmers and of farmers that received credit and to compare them with their counterfactual expectation. The counterfactual scenarios for the constrained farmers are the average production values that they would have produced, if they had not been constrained. On the other hand, the counterfactual scenarios for the farmers with credit are the average production values that they would have produced, if they had not received credit. Thus, taking the significant parameters from **Table 42** section $\eta[s\Phi]$, $(\delta - \beta)[x\Phi]$, and $(\rho_1 - \rho_2)\phi$, we estimated (14) using the average values of the observable variables of the constrained farmers and of the farmers with credit, and the average values of the $\phi/\Phi$ for the both groups.

[57] Note that we are testing the statistical difference between $\rho_1$ and $\rho$ and between the parameters of each equation (regime). In **Appendix 7** we present the estimations of each regime using the Heckman's procedure. The results of the estimations confirm that $\rho_1$ and $\rho_2$ are individually significant for most of the cases, which proves the presence of selection bias.

We separated the total effect in indirect effect and effect direct. The indirect effect is composed of observable and unobservable factors, and the direct effect is only applicable to the case of credit. Additionally, in order to confirm the statistical importance of the observable factors, a Wald test was carried out testing the hypothesis that all the variables in this group are jointly zero. The results are shown in **Table 42**, from which is not possible to reject such a hypothesis in crop production for the case of credit and in mix production for the case of credit constraint.

**Table 43**
**Impact on the average production value of credit constraint and credit (based on Table 42)**

| EFFECTS | Credit | | | Credit constraint | | |
|---|---|---|---|---|---|---|
| | CROP | LIVESTOCK | MIX | CROP | LIVESTOCK | MIX |
| **Direct effect of credit** | ***0.00*** | ***0.00*** | ***0.00*** | | | |
| **Indirect effect** | | | | | | |
| **Observed factors** | *0.00* | *-0.36* | *0.14* | *0.20* | *-0.12* | *0.00* |
| **Unobserved factors** | *0.00* | *0.00* | *0.00* | *0.66* | *0.00* | *0.00* |
| **Total Effect* = E($y_{1i}$ \|D = 1) – E($y_{2i}$ \|D = 1)** | ***0.00*** | ***-0.36*** | ***0.14*** | ***0.86*** | ***-0.12*** | ***0.00*** |

* Total effect is the change of logarithm of production value, which is equivalent to its percentual change
Source: Own calculations using survey data

**Table 43** shows the results of *impact on the average production value associated with each treatment*, which represents a percentual change[58] because we are measuring the variable dependent (on farm income) in logarithm. We can see that in the three sectors the *direct* impact of credit and unobserved factors do not have any effect on the production value. However, credit in livestock and mix production generates important *indirect* effects associated with observable variables. Effectively, credit has decreased the average production value in a 36% in livestock, and has increased it a 14% in mix production[59]. Contrary to what was expected, the impact of credit on livestock production is negative, which means that if the farmers had not received credit, they would have increased their production levels in 36%[60]. This result could be associated with the use given to credit, in particular when in such activity

[58] Because the prices are incorporated in the production value, the interpretation of the results should be analyzed with caution. Thus, the value could change for both in prices and in production changes. We hope that the dummy variables of localization incorporated in the estimations capture any differential in prices.

[59] Similar results were obtained using an alternative specification in the first stage. Following Sial and Carter (1996), we used a Tobit model instead of a Probit model. From this specification, we got the Inverse Mills Ratios (IMR), incorporated them in OLS regression of the second stage, and corrected the estimation for heteroscedasticity by using robust standard errors (White, 1980). The results are presented in **Appendix 8**.

[60] In order to review the impact of credit on the production value, we leave out the variable LWC of the original estimations because of its collinearity with CRED. The coefficients of correlation are 0.45, 0.55, and 0.49 for crop, livestock and mix production, respectively. The results are presented in **Appendix 9**, which confirm our previous estimations.

the intermediate inputs are not as clear as in crop production, and credit could have been spent on items that are not related to production activities. Those results suggest that credit has not had the expected effect, which could be explained by a wrong allocation among farmers, and the lack of competitive advantages of those who got credit in relation to those who did not.

On the other hand, the condition of credit constraint shows that the observable factors play a role in the sectors of crop and livestock. Additionally, the unobservable factors were only relevant in crop production. Thus, the total effects of credit constraints show a 12% lower production value in livestock production as a consequence of the constraint. This suggests that livestock farmers constrained are able to get lowers production values in comparison to a context without constraint. In other words, if those farmers had not been constrained, they would have increased their production value by 12%. Conversely, crop production increases 86%, which means that constrained farmers get to increase their production by 86% in relation to a situation without constraint. In other words, if those farmers had not been constrained, they would have decreased their production value by 86%. This result goes in the opposite direction to what was expected, the unobserved factors being the main component in explaining it. The interpretation of this result is not easy and maybe it is related to higher incentives as a consequence of being constrained, which could be activating unknown abilities and capacities that produce a higher efficiency in production. However, given that we could not find evidence in favor of the normality assumption in crop production, this result is not plausible.

# Chapter VIII

# Conclusions and future research

## 8.1 Conclusions

### 8.1.1 Study 1: *Financial Markets and the Determinants of Technical Inefficiency among Specialized Small Farmers*

In the context of fast growth, the Chilean agricultural sector has not had time to analyze what is going on in its small agriculture. Small farmers are characterized by heterogeneity, limited technology and a constrained capital market. Proof of this is the lack of studies which could help public policy in the design and implementation of more suitable instruments. Since the beginning of this decade, this situation has become more complex owing to new trade agreements. This new situation seems to provide opportunities for livestock production but threatens for crop production.

Using a wide sample of small farmers collected in 2004, we studied two groups of specialized producers, crop and livestock, analyzing their technologies, levels of technical efficiency, and the relation between access to the capital market and technical efficiency. We focused on specialized producers because it is easier to model their technology, and selected those sectors because they are basically composed of small farmers and have different perspectives of development in the Chilean economy.

Using a parametric approach, we estimated stochastic production functions for 109 livestock and 342 crop producers. Those samples show that in crop production 33% of farmers got credit and 41% were constrained, and in livestock production 27% of farmers got credit and 43% were constrained. The results show that a technology translog and heteroscedastic inefficiency model represents better the available data than a Cobb Douglas technology. In general, the technologies studied are well-behaved in terms of satisfying the regularity conditions. At the sample mean, the crop production shows return constant to scale, and the livestock production presents increasing return to scale, suggesting that the latter ones are operating at a sub-optimal size. In relation to that, a discussion concerning the suitable size of cattle producers has emerged during the last years in Chile as a consequence of the strong competition with the members of MERCOSUR and, therefore, this result clearly reinforces this discussion.

In crop production, localization and quality of land, measured as proportion of irrigated land, are important factors that help to explain differences in the levels of on-farm income among farmers. The inputs considered were significant, with the exception of the proxy of capital (animal market value), a result that is in line with other studies at the small farmer level. The elasticity of intermediate inputs, using the variable working capital as proxy, is in the rank of 0.69-0.57, depending on whether farmers have or do not have irrigation. An interesting finding is that one hectare with irrigation is more than 7 times more productive than one without irrigation.

On the other hand, livestock production shows different results. First, localization factors are not important and irrigation is only significant in making a little difference between elasticity of intermediate inputs (working capital) with and without irrigation. Second, consistent with other studies, the labor force and the land are not relevant inputs in the modeling of this type of technology, suggesting their relative abundance. It is not possible to discard the fact that the labor force plays the role of a buffer in the agricultural economy of the country's southern zone; however, we do not reject the possibility of facing problems with the family labor force estimations. Third, at sample mean level, the elasticities of intermediate inputs (working capital) and capital (animal market value) are significant with values of 0.51 and 0.84, respectively.

The sample analyzed shows that crop production has a mean efficiency of 89% with a great number of farmers getting high efficiency scores, and the confidence intervals reveal a higher accuracy of our estimations for scores larger than 0.75. Livestock production shows a mean efficiency of 78% and wider confidence intervals for efficiency scores between 0.50 and 0.75. In general, it is possible to say that technical efficiency increases with decreasing use of inputs, a higher dependence of the on-farm income, more educated farmers, bigger family size and older head of family. The variable of public policy, measured as the participation of household in any INDAP program, is not significant in crop production, unlike in livestock production. The latter result would be in line with INDAP support given to this kind of small farmer by means of direct subsidies for improving both grasslands and animal stocks. On the other side, extension services do not seem to help farms in getting higher levels of technical efficiency; even in the case of crop production, those services act directly opposite than expected, so that farms that received extension service are less efficient than those that did not. This result is disappointing because it shows either a bad quality of provided service, or farms that do not follow the technical recommendations. However, this finding should be regarded with caution because we are indeed measuring the efficiency on the value of total production and not on the physical amount of output.

Observing differences in the impact in each sector, the variables related to the formal credit market are important in explaining technical inefficiency. According to the literature reviewed, there is not a consistent theoretical framework that helps us understand the impact of financial variables on technical efficiency, at least at the small farm level. We are a little critical of this literature and believe that the result will finally be an empirical issue, which will apparently be influenced by the characteristics of each study case.

The estimations for crop specialized producers indicate that credit has a positive impact on efficiency, supporting the theories of free cash flow, credit evaluation, embodied capital and credit as insurance. However, we believe that this finding is explained by the existence of a more structured credit market in the sector as a consequence of the country's agricultural history, a closer relation between necessities of short-term credit and operations, and a simplification in the collateral use. On the contrary, in livestock production, credit has a negative impact on the efficiency, supporting theories of agency cost and adjustment. We argue that, from the beginning of 2000, the perspectives of livestock production in small farmers have improved, which could have been forcing producers to make investments using short-term credit because of the lack of long-term credits. In this context, credit could have been used in activities that do not necessarily have an impact on annual production.

On the other hand, constrained farmers are less efficient in crop production and more efficient in livestock production. We do not have a plausible explanation for this, but we believe that these findings open a new way to analyze the extent of credit constraint in agriculture and, in particular, in small farmers. According to our results, from a technical efficiency perspective, it would be bad to face credit constraint in crop production because the levels of efficiency of constrained farmers would tend to be lower than unconstrained farmers. On the contrary, in livestock production, the result would be opposite because a constrained farmer would be more efficient than an unconstrained one. Although we do not have an explanation for this, we can stress the importance of using stochastic frontier analysis to have a more quantitative approximation of this phenomenon. The literature that has studied the extent of credit constraint in agriculture has focused on the impact on agricultural production; however, we believe that it would be more interesting to analyze its impact on some development goal, as is the case of efficiency.

Additionally, we checked the possibility of simultaneity between technical efficiency and the variables related to the credit market in our results. Using the Durbin-Wu-Hausman test, we can not reject the hypothesis of no simultaneity in crop production, but we can do it in livestock production, suggesting any kind of feedback from the levels of efficiency to the variables related to the credit market. We justify this finding from an institutional perspective; lenders would have more information and knowledge of farmers in livestock production. This situation would be the result of a public policy oriented to sectors with a more direct exporting orientation.

The livestock estimation was corrected by taking the fitted values from the Tobit and Probit models as instruments of the financial variables. Those estimations confirm our previous results; however, this procedure affected other parameters both in the production function and the inefficiency model. Basically, the elasticity of capital (measured as the variable animal market value) increased, the elasticity of intermediate inputs (measured as the variable working capital) decreased, the proportion of irrigated land was no longer significant, and the interaction between the two inputs considered was significant and positive, suggesting a complementary relationship between them.

Finally, from an empirical application point of view, the results found stress the necessity of checking endogeniety in the variables used to model the inefficiency effects. On the other hand, at the Chilean economy level, we can mention that the variables that are behind efficiency are different in each sector analyzed both the variables related to formal credit market and the rest of variables analyzed, which should be considered by policy makers in order to improve their policies.

### 8.1.2 Study 2: *Technical Efficiency and Off-farm activities among Non-specialized Small Farmers*

Diversification and new income sources, and in particular, the development of off-farm activities, have been strongly claimed as solutions to the difficult situation of a great numbers of small farmers. Such initiatives need a public policy not only coherent in the medium term but also based on diagnostics as precise as possible concerning the actual situation of target groups. The problem is that the impact on small farmers of initiatives as mentioned is not clear because there is not enough research about it. Therefore, it is fundamental to advance in the understanding of the factors that are behind the decision-makers and to try to quantify essential measurements such as technical efficiency. To do that, we use a stochastic frontier analysis to estimate the levels of technical efficiency and identify factors that explain them.

Using a country-wide sample, we studied the case of 384 Chilean non-specialized small farmers. In order to take into account different production structures, we divided the sample into three groups: 165 mixed farmers, 115 crop-oriented and 104 livestock-oriented. Thus, we are able to estimate a translog production function by considering different intensities in the use of inputs. To do that, we model the production function with different intercepts and slopes associated to each group of farmers in order to capture, from a statistical point of view, differences both in their mean incomes and in their partial production elasticities. Moreover, we used dummy variables of localization and the variable proportion of irrigated land as control variables in the modeling.

We use the Caudill and Ford's (1995) model and the scaling property to model the variance of the inefficiency. This permits us to improve the estimation of the parameters of the production function and directly interpret each parameter of the inefficiency model as its marginal effect. According to our knowledge, this is the first application of this type of methodology to small farmers. Additionally, we innovate in the literature of efficiency by taking into account the potential endogeneity of two important variables in our inefficiency model; the amount of credit and the household participation in off-farm activities.

The endogeneity was checked by using the Hausman-Wu-Durbin test, which is based on the significance of the residuals of auxiliary regressions for each variable with potential endogeneity. Thus, a Tobit model was run for the variable credit and a Probit model for the variable participation in off-farm activities. The endogeneity was not rejected and, in the spirit of two stages least square, we used the fitted values in place of original variables.

Independently whether endogeneity is taken into account or not, the technology is well-behaved with a production function homothetic and constant return to scale. We found evidence of differences among types of producers, not only in their mean production levels but also in their production structures (elasticities). Three out of four inputs analyzed were relevant in the modeling, where the variable used land (LAM) was not significant in any estimation, either individually or in their interactions. The partial production elasticities of working capital, labor force and animal market value, at sample mean level, are significant for each kind of farmer. For example, when endogeneity is taken into account, the working capital elasticity fluctuates between 0.21 and 0.57, depending on the type of producer and the availability of irrigation. On the other hand, when endogeneity is considered this elasticity fluctuates between 0.19 and 0.48.

The control variables are important to capture environmental factors in the modeling of the technology, explaining differences in the mean on-farm incomes. Farmers located in macro zones 4 and 5 can get lower on-farm income levels than anywhere in Chile. On the other hand, the variable related to irrigation (PIA) makes differences in productivity between land with and without irrigation. For example, in the case of the mixed producers, one hectare with irrigation is more than 5.2 times more productive than one without irrigation. Unlike when the endogeneity is analyzed, the control variables maintain their effect on the production except for the variable PIA, which is no longer significant at the 5% level.

The inefficiency is properly explained by the variables considered and the estimation improves when the variance of the inefficiency term is modeled. Depending on whether the endogeneity is taken into account or not, the mean efficiency is 84% and 72%, respectively. More variables explain the inefficiency when the endogeneity is considered. In fact, apart from family size and share of on-farm income on the total income, the level of education of the head of family, the efforts for improving the management, and a production biased towards livestock activities contribute with higher efficiency levels. This suggests that the non-specialized farmers are more efficient as soon as they are livestock-oriented and there is not evidence to support the diversification as a factor that promotes the technical efficiency. Within the common variables that decrease the technical efficiency are the increasing use of the inputs working capital and labor, and the household participation in off-farm activities. Additionally, as soon as we take into account endogeneity, the age of the head of family, and the condition of receiving extension services negatively contribute with the efficiency. The last one would suggest that the efforts of extension have not produced the effects expected and, on the contrary, have gone in the opposite direction. In addition, notice that the variables proxies of participation in off-farm activities and the importance of the off-farm income on the total income are measuring, at the same time, two important issues. First, the impact of the participation of the household in off-farm activities on the technical efficiency by mean of DOFF. Second, the magnitude of this participation on the technical efficiency by mean of the variable SHA, because a higher value of SHA implicitly implies a lower magnitude of participation in off-farm activities.

Contrary to what was expected, the variables used land, credit, and participation in INDAP were not significant. The land was not a relevant input in the production decisions for any group of farmers, which could be showing a highly competitive land market or could be simply because we are measuring the efficiency over the value of total output, hiding the technological relationship between outputs and used land. The credit is not a factor determinant in the efficiency levels probably because the non-specialized farmers face constraints more related to management skills, and their diversified production structures permit them to smooth more easily the production-consumption cycles. On the other hand, the participation in INDAP seems not to improve the efficiency, measuring it either by the participation in some INDAP general program or by the participation in the credit program.

Thus, if the objective for non-specialized Chilean small farmers is to reach higher efficiency levels, then a higher diversification and participation in off-farm activities do not help them. Moreover, after comparing the best models with and without endogeneity, we can get some interesting findings. First, the mean efficiency decreases; second, more variables explain the variance of the inefficiency; and third, there are changes in technological parameters, not only in the partial production elasticites, but also in the interactions among inputs. Those results confirm the finding found in Chapter V, it is important to check endogeneity of the variables that model *the inefficiency effects*.

### 8.1.3 Study 3: *Credit and Production: A micro-econometric Study of Small Farmers*

The link between credit and agriculture has been of great interest during recent years, and several papers that have covered different angles of this issue. The relationship between credit and production has been one angle, which has basically explored how technological adoption decisions, credit constraints, and credit impact on production. Additionally, the analysis of credit rationing has been a central theme, in particular, modeling situations of equilibrium with rationing, which is fundamentally explained by information asymmetries in the rural credit markets. On the other hand, in disequilibrium credit markets, the hypothesis of *liquidity* has received some attention, which basically claims that the separability of consumption and production decisions at the household level is broken due to credit constraints, and production decisions of constrained producers are influenced by the consumption decisions.

The empirical applications have fundamentally used the technique switching regression model, which is based on the assumption of bivariate normality of the errors. The basic idea behind this technique is that there are different equations between two groups, which are separated by some known criterion, generally a Probit function. Thus, in the modeling of each group we should expect differences, from a statistical point of view, among the parameters of each equation; otherwise the separation does not make sense. Under this premise, we found that most of the studies conducted did not check those elements, which weakens their results.

Using data from a country-wide sample for the Chilean case, the relationship between rural credit markets and agricultural production for small farmers is explored. The sample was divided into three groups; crop producers (457), livestock producers (213) and mixed producers (165). Thirty percent of livestock producers had credit and 45% were constrained; a quite similar situation was observed in crop and mixed producers with figures of 37% and 40% for those who had credit, and 46% and 45% for those who were constrained, respectively. However, for those who had credit, its importance in the total financing was remarkably different depending on each sector and its specialization. Thus, on average credit accounted for between 54% and 41% for the crop producers, in livestock production represented between 48% and 40%, and in mix production was 28%. In general, more than 70% of formal rural financing comes from INDAP, followed by BancoEstado with 20%. Moreover, crop production is basically concentrated in four crops (wheat, maize, potatoes and rice), which accounts for 80% of the used land, and takes place in the country's central area. On the other hand, livestock production is basically composed of cattle, sheep and goats; however, from the animal weight unit point of view, the stock of cattle accounts for 75% of the endowment of livestock, which is mainly localized in the southern zone.

Switching regression models were used in this work, and the normality assumption, which is a basic element in this type of model, was tested. The results show that this assumption was not fulfilled in crop production, which should be taken into account in the interpretation of the results.

According to our knowledge, this work is the first that tests the hypothesis of Liquidity based on a theoretical model by using Full Information Maximum Likelihood (FIML). Focusing on the parameters of the variables credit (CRED) and number of dependents (NDEPEND), we could not find evidence in favor of this hypothesis in the three groups analyzed. Those results could be indicating either a wrong classification of the farmers between constrained and unconstrained or a weak theoretical model, and, therefore, they should be only interpreted as preliminary evidence.

Additionally, this work is the first one that evaluates the "impact" of both *credit constraints* and *credit* on the average agricultural production of small farmers in Chile based on the literature of treatment effects. We understand by *impact* the change in the average production between the treated (regime 1) and untreated farmers (regime 2). Two types of treatments are considered; one treatment is when a household receives credit (regime 1), and the other treatment is when household is constrained (regime 1).

Thus, we have to deal with nonrandom data, problems of selection and unobserved heterogeneity; however, important advances in econometric modeling permit us to solve the inconsistency of the estimated parameters under this context by estimating a switching regression model in two stages using the entire sample in each group. Thus, we are able to consistently estimate the parameters of the model. In the first stage, we estimated a Probit model to explain the probability of belonging to each group; constrained or unconstrained, and with credit or without credit. In second stage, we estimated an OLS regression using the entire sample. This procedure permitted us to statistically test differences in the parameters of each regime.

The results of the Probit models (first stage) confirmed the necessity of studying each sector separately, because we could see that the variables that explain the conditions of credit constraint and credit in each sector are different. The OLS estimations (second stage) fitted quite well with R-squared, which fluctuated between 0.71 and 0.79, and the F-tests confirmed the formulation of the models. From those regressions, we observed that a few parameters were statistically different between the two regimes in each sector for both the case of credit constraint and credit, which could be explained by the cross-sectional data used.

The effects of *credit constraints* on the production value is positive in crop production (86%), there were not observed effects in mix production, and is negative in livestock production (-12%). The last result suggests that livestock farmers constrained are able to get lowers production values in comparison to a context without constraint. In other words, if those farmers had not been constrained, they would have increased their production value by 12%. The interpretation of result got in crop production is not easy and maybe it is related to higher incentives as a consequence of being constrained, which could be activating unknown abilities and capacities that produce a higher efficiency in production; however, according to the tests of normality conducted, that result should not be plausible.

On the other hand, the total effect of *credit* increases the production value in mix production (14%) and decreases it in livestock production (36%), without effect on crop production. This finding suggests that in crop and livestock production the descriptive association between credit and production performance is a spurious result of the fact that those who produce with credit face a more favorable environment and/or are intrinsically better producers even without credit. It is appealing to conclude that credit was chosen by these individuals for non-production reasons, and that credit had none of its projected economic impacts. Those results also suggest that credit has not had the expected effect, which could be explained by a wrong allocation among farmers, and the lack of competitive advantages of those who get credit in relation to those who do not.

From an empirical perspective, the results of this work point out the necessity of checking bivariate normality and testing the difference between the parameters of the regimes in order to justify the use of a switching regression model; otherwise, the results obtained could not make sense.

## 8.2 Future Research

The following lines of future research arise from the results of this thesis.

- It is important to evaluate in more detail the role of public policy and extension services on technical efficiency using more specific data. For example, to evaluate the effects of extension services would be more suitable to use the number of visits or expenditures in extension instead of a binary variable.

- The estimation procedures should be improved when endogenous variables are explicitly considered in the inefficiency models.

- Deeper research is needed to analyze the interaction between decisions to participate in off-farm activities and rural development in Chile, for example, one improvement would be to use continue variables such as work hours in off-farm activities.

- New elements should be incorporated to improve the evaluations of impact on average production. It would be interesting to advance in studies that incorporate risk, and semi-parametric techniques to deal with selection processes. Additionally, it is necessary to integrate the techniques of stochastic frontier analysis and switching regression models in a clearer and consistent way.

- The policies regarding lending should be reviewed because credit has been apparently focused on farmers with no latent skills. Therefore, there is necessity of deeper studies on this issue.

- It should be studied in Chile if credit is the less expensive financing source, and also if one more effective way to improve the allocation of financial resources in rural areas is to strengthen the financial intermediation with informal intermediaries.

- It is necessary to build more systematic and reliable data base in order to follow improving the diagnostics of small farmers, a task that in the current institutional-political structure should be led by INDAP in the next few years.

# Chapter IX

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# Appendix 1

# Interview

## Encuesta Servicios Financieros Pequeña Agricultura

RIMISP

### 1. Identificación.

Región ____ Comuna ____

Tipo de cliente ____
1. INDAP vigente
2. INDAP moroso
3. INDAP sin crédito
4. Control

Numero correlativo ____

Compara con: Sólo para muestra tipo 4, indique el número correlativo del tipo INDAP que controla ____

SR. ENCUESTADOR: ANTES DE COMENZAR LA ENTREVISTA:
(A) IDENTIFÍQUESE CON SU NOMBRE Y APELLIDO. (B) LEA O EXPLIQUE LOS OBJETIVOS DE LA ENTREVISTA. (C) PIDA EL PERMISO DE LA PERSONAS PARA HACERLE LA ENTREVISTA.

1.1 Nombre encuestador ____

1.2 Fecha entrevista ____

1.3 Hora de la entrevista ____

**Identificación de la explotación**

1.4 Región ____

1.5 Comuna ____

1.6 Localidad ____

1.7 Dirección ____

1.8 Nombre entrevistado ____

1.9 Teléfono fijo o celular ____

1.10 Relación con jefe de hogar ____

1.11 Distancia a camino principal (Km) ____

EN CASO DE QUE EL ENTREVISTADO HAYA RECHAZADO LA ENCUESTA. POR FAVOR SEÑALE LAS RAZONES.

EN CASO DE QUE LA DIRECCIÓN DEL ENTREVISTADO SEA DE DIFICIL ACCESO, POR FAVOR SEÑALE LAS INDICACIONES DE COMO LLEGAR. EN CASO DE SER NECESARIO, USE EL REVERSO DE LA PAGINA

1

## 2. Demográfico

Tipo de Cliente: ______ N° Correlativo: ______

**RegiónSeñor(a): Quisiera pedirle que por favor pensemos en el período entre 1º de Mayo del año pasado (2003) y 30 de Abril de este año (2004). Por favor, me puede decir cuántas personas vivieron en ese período de tiempo aquí con usted, es decir, cuántas personas vivieron compartiendo la misma vivienda y los mismos alimentos, ya sean familiares o personas que no son familiares pero que vivieron con ustedes. Si hay personas que vivieron menos de tres meses seguidos, entonces a ellos NO los incluimos.**

| 2.1 Nº de orden | 2.2 Nombre | 2.3 Indique relación con base de datos de usuarios de crédito de INDAP | 2.4 Sexo | 2.5 Edad | 2.6 Estado Civil | 2.7 Parentesco con jefe de hogar | 2.8 Nivel educacional | 2.9 Participa en organizaciones | 2.10 Tipo de organización | | | | 2.11 Cúal es la actividad principal de los miembros del hogar? |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| entrevistadoN°1 | | 1. Pertenece a la base de datos<br>2. No pertenece a la base de datos | 1. Mujer<br>2. Hombre | años cumplidos | 1. Casado<br>2. Soltero<br>3. Conviviente<br>4. Viudo/a<br>5. Separado | 1. Jefe de Hogar<br>2. Cónyuge<br>3. Hijo(a)<br>4. Padre, madre<br>5. Suegro (a)<br>6. Yerno, nuera<br>7. Nieto (a)<br>8. Hermano (a)<br>9. Cuñado(a)<br>10. Otro familiar<br>11. Otro no familiar<br>12. S. Doméstico | (Años de estudios aprobados) | 1. Si<br>2. No | 1. Religiosa<br>2. Deportiva<br>3. Comunitaria<br>4. Sindical<br>5. De productores para vender<br>6. De productores para comprar<br>7. Comité de productores (comité campesino)<br>8. Comité de regantes<br>9. Junta de vecinos<br>10. Otra<br><br>Puede considerar hasta 4 tipos por persona completar por orden de importancia según entrevistado | | | | 1. Trabajo cuenta propia en agricultura<br>2. Estudiante<br>3. Dueña de casa<br>4. Trabajo asalariado<br>5. Trabajo por cuenta propia no agrícola<br>6. Cesante<br>7. Jubilado<br>8. Otro, especifique<br>9. No Aplica (NA) |
| | | | | | | | | | 1 | 2 | 3 | 4 | |
| 1 | | | | | | | | | | | | | |
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| 10 | | | | | | | | | | | | | |
| 11 | | | | | | | | | | | | | |
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2

## 3. TRABAJO ASALARIADO, EMPLEO POR CUENTA PROPIA NO AGRÍCOLA Y OTROS INGRESOS

**Tipo de Cliente:** ______ **N° Correlativo:** ______

**Señor(a): Ahora le voy a preguntar si acaso alguna de las personas del hogar MAYORES DE 15 AÑOS trabajaron la temporada pasada (entre Mayo del 2003 y Abril del 2004) , en algún empleo a cambio de un sueldo o un salario, ya sea con contrato permanente, mensual, por temporada, por semana, a trato o al día.**

**También nos interesa saber si tuvo algún trabajo por su propia cuenta, es decir, sin tener patrón como por ejemplo, un pequeño negocio, fábrica de mermeladas, campings, tener un puesto en la feria, u otros de este tipo.**

| 3.1 Trabajo asalariado temporal | | | | | | 3.2 Trabajo asalariado permanente | | | | | 3.3 Trabajo por cuenta propia no agrícola | | | | 3.4 ¿Recibe otro tipo de ingreso? | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| N° de orden Indique el N° de orden según 2.1 | Actividad principal del trabajo temporal<br>1. Agrícola<br>2. Pesca<br>3. Forestal<br>4. Minería<br>5. Servicios<br>6. Comercio<br>7. Construcción<br>8. Taller mecánico<br>9. Agroindustria<br>10. Industria<br>11. Otro<br>12. N.A | ¿Qué labor realizá?<br>Anote con palabras | Tiempo que realizó esta actividad durante 2003<br>1. Dias<br>2. Semanas<br>3. Meses | | Salario recibido por esta actividad en relación al código señalado | Actividad principal del trabajo permanente<br>1. Agrícola<br>2. Pesca<br>3. Forestal<br>4. Minería<br>5. Servicios<br>6. Comercio<br>7. Construcción<br>8. Taller mecánico<br>9. Agroindustria<br>10. Industria<br>11. Otro<br>12. N.A, especifique | ¿Qué labor realizá?<br>(Anote con palabras) | Antigüedad en el trabajo<br>(años) | ¿Tiene contrato?<br>1. Si<br>2. No | ¿Cúal es el salario mensual?<br>(Anote salario líquido) | Actividad principal<br>(Anote en palabras) | ¿Tiene iniciación de actividades, por esta actividad?<br>1. Si<br>2. No | Total de ventas en dinero en todo el año | Costos totales que demanda esta actividad en todo el año | Tipo de ingreso<br>1. Pensión asistencial<br>2. Asignación Familiar<br>3. Subsidio de cesantía<br>4. Pensión de alimentos<br>5. Montepío, pensión de viudez<br>6. Remesas externas<br>7. Jubilación<br>8. Otros. Especifique | |
| | | | **cod.** | **cant.** | **$/ código** | | | | | | | | **$/año** | **$/año** | **Tipo** | **Monto / mes** |
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| | | | | | | | | | | **SUMA DE COSTOS TOTALES (suma 3)** | | | | | |

3

## 4. TENENCIA DE LA TIERRA

Tipo de Cliente: ______ N° Correlativo: ______

**Señor(a): Ahora quisiera hacerle algunas preguntas sobre las hectáreas de las que dispone. Pensando siempre en la temporada pasada, es decir, entre Mayo del 2003 y Abril de este año (2004). No sólo las tierras suyas, sino todas las de los miembros de su hogar.**

| | Total de hectáreas | Valor estimado por hectárea ($) | Por favor, indique quién es la persona del hogar que controla la tierra en cada item (por ejemplo: quién es el propietario, quién es el que arrienda, quién recibe en medias, etc). Incorpore el número de orden según la pregunta N° 2.1 |
|---|---|---|---|
| 4.1. ¿De cuántas hectáreas dispuso el último año agrícola? (mayo 2003/abril 2004) | | | |
| 4.2 De estas hectáreas ¿cuántas son propias con título de dominio? | | | |
| 4.3 ¿cuántas son de una sucesión? | | | |
| 4.4 ¿cuántas son cedidas? | | | |
| 4.5 ¿cuántas son de usufructo? | | | |
| 4.6 ¿cuántas son comunitarias? | | | |
| 4.7. ¿Cuántas son arrendadas? | | | |
| 4.8. ¿Cuántas entrega en arriendo? | | | |
| 4.9. ¿cuántas recibe en medias? | | | |
| 4.10. Cuántas entrega en medias? | | | |
| 4.11 Cuántas entrega en usufructo? | | | |
| 4.12 Cuántas recibe en usufructo? | | | |
| 4.13. De las hectáres que dispuso el año pasado ¿Cuántas se pueden regar? | | | |

## 5.GESTIÓN Y ADMINISTRACIÓN

| **Señor(a): Ahora quisiera hacerle algunas preguntas sobre la parte de administración de su campo o negocio. Recuerde que siempre estamos pensando en la temporada pasada, entre Mayo 2003 y Abril de este año (2004).** | 1. Si<br>2. No | ¿Cuánto paga al año por el servicio? | Desde cuándo que tiene este servicio<br><br>(Anote año) | Por favor, indique quién es la persona del hogar que se relaciona con cada servicio. Incorpore el número de orden según pregunta Nº 2.1. | | | | |
|---|---|---|---|---|---|---|---|---|
| 5.1. Ud. o algún miembro del hogar, tiene o contrata alguno de los siguientes servicios? | | | | | | | | |
| 5.2. Asesoría técnica particular | | | | | | | | |
| 5.3. Asesoría técnica INDAP | | | | | | | | |
| 5.4. Asesoría en gestión comercial | | | | | | | | |
| 5.5 Atención veterinaria | | | | | | | | |
| 5.6. Téléfono red fija o móvil | | | | | | | | |
| 5.7. Sistemas de registro de la empresa | | | | | | | | |
| 5.8. Capacitación en administración | | | | | | | | |
| 5.9. Capacitación en manejo predial | | | | | | | | |
| 5.10. Trabajadores contratados permanentes | | | | | | | | |
| 5.11. Contrato agroindustria | | | | | | | | |
| 5.12. Contrato exportadora | | | | | | | | |
| 5.13. Contrato supermercado | | | | | | | | |
| 5.14. Otro contrato | | | | | | | | |
| 5.15. Acopio | | | | | | | | |
| 5.16 . Ud o algun miembro del hogar usa Internet para tomar decisiones sobre la administración del negocio o del campo? | | | | | | | | |
| **SUMA DE PAGOS ANUALES (favor sumar ítemes 5.1 a 5.16)** | **suma 5** | | | | | | | 4 |

Tipo de Cliente: ______ N° Correlativo: ______

| 5.17 Ud. o algún miembro del hogar es beneficiario de alguna de las siguientes instituciones o programas? | 1. Si<br>2. No | En caso de que si, anote el N° de orden de la persona que participa en el hogar | | | | | | |
|---|---|---|---|---|---|---|---|---|
| INDAP (Instituto de Desarrollo Agropecuario) | | | | | | | | |
| FOSIS (Fondo de Solidaridad en Inverión Social) | | | | | | | | |
| PRODESAL (Programa de Desarrollo Asesoría Local) | | | | | | | | |
| Programa PUENTE | | | | | | | | |
| SENCE (Servicio Nacional de Capacitación y Empleo) | | | | | | | | |
| CORFO (Corporacioón de Fomento) | | | | | | | | |
| CNR (Comisión Nacional de Riego) | | | | | | | | |
| CONAF (Corporación nacional Forestal) | | | | | | | | |
| CONADI (Corporación Nacional de Desarrollo Indígena) | | | | | | | | |
| Programa Orígenes (Mideplan- BID) | | | | | | | | |
| OTROS | | | | | | | | |

## 6. ESTRUCTURA DE USO DEL SUELO

**Señor(a) Ahora quisiera hacerle algunas preguntas sobre los cultivos, los frutales, animales y otras actividades agrícolas. Le recuerdo que nos interesa la temporada que acaba de terminar, es decir, entre Mayo del año pasado (2003) y Abril de este año (2004). Además, en esta parte queremos preguntarle de todo lo que se hizo en los terrenos tanto propios como los que hicieron en medias o los que cultivaron en los terrenos que tomaron en arriendo o en otro tipo de tenencia. No sólo los cultivos suyos, sino todos los de los miembros de su hogar**

| **6.1 Cultivos** | Sup. | Producción Cantidad | Unidad medida<br>1. Kilos<br>2. Sacos (80kg)<br>3. Quintales<br>4. Toneladas<br>5. Unidades | Cantidad vendida | Precio venta por unidad | Lugar de venta<br>1. Predio<br>2. Bodega local<br>3. Agroindustria<br>4. Feria<br>5. Supermercado<br>6. Otro | Costos de producción del cultivo. Incluye (insumos, mano de obra contratada y maquinaria arrendada) | | Jornadas trabajo No pagada en todo el cultivo en el año | Por favor, indique quién es la persona del hogar que controla o toma decisiones respecto de la producción de cultivos. Incorpore el número de orden según pregunta N° 2.1.<br>* Si un mismo cultivo es controlado por dos personas favor complete un registro independiente para cada una |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | Ha. | Valor total | | |
| | | | | | | | | | | |
| | | | | | | | | | | |
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| | | | | | | **TOTAL suma 6.1** | | | | |

| **6.2 Huerto Frutal o Quinta**<br>Anote el codigo de las principales especies. | Sup. | Edad | Producción Cantidad | Unidad medida<br>1. Kilos<br>2. Sacos (80kg)<br>3. Quintales<br>4. Toneladas<br>5. Unidades | Cantidad vendida | Precio venta por unidad | Lugar de venta<br>1. Predio<br>2. Bodega local<br>3. Agroindustria<br>4. Feria<br>5. Supermercado<br>6. Otro | Costos de producción del cultivo. Incluye (insumos, mano de obra contratada y maquinaria arrendada) | Jornadas trabajo No pagada en todo el cultivo en el año | Por favor, indique quién es la persona del hogar que controla o toma decisiones respecto de la producción del huerto frutal. Incorpore el número de orden según pregunta N° 2.1.<br>* Si un mismo cultivo es controlado por dos personas favor complete un registro independiente para cada una |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | |
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| **ATENCION: En cuadro 6.2 si la uva se vende como vino anote en cuadro 8, en su efecto en cuadro 6.** | | | | | | | **TOTAL suma 6.2** | | | 5 |

Tipo de Cliente: ______ N° Correlativo: ______

| 6.3 Invernaderos<br>Señalar el tipo de invernaderos<br>1. Flores<br>2. Hortalizas | Sup. (m2) | Ingreso de la producción | Costos de la producción | Ingreso Neto | Ingreso NetoPor favor, indique quién es la persona del hogar que controla o toma decisiones respecto de la producción del huerto frutal. Incorpore el número de orden según pregunta N° 2.1.<br>* Si un mismo cultivo es controlado por dos personas favor complete un registro independiente para cada una |
|---|---|---|---|---|---|
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| | | | | | |
| | | | | | |
| | | TOTAL suma 6.3 | | | |

| | Monto ($) |
|---|---|
| 7.1 ¿Cuánto gasta Ud en praderas en el año? | |
| 7.2 ¿Cuánto gasta Ud en sanidad animal en el año? | |
| Suma 7 | |

## 7. DOTACIÓN DE ANIMALES Y PRODUCCION DE LECHE

| Animal (código) | N° animales | ¿Cuántos vendió? | Precio por unidad | ¿A quién vende normalmente?<br>1. Intermediario<br>2. Vecinos<br>3. Comercio<br>4. Planta lechera<br>5. Feria<br>6. Matadero<br>7. Centro acopio<br>8. Otro especifique | Por favor, indique quién es la persona del hogar que controla o toma decisiones respecto de la producción de leche y manejo animal. Incorpore el número de orden según pregunta N° 2.1. |
|---|---|---|---|---|---|
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| | | | | | |
| | | | | | |
| | | | | | |
| | | litros/año/vaca | $ /litro | | |
| Vacas propósito leche | | | | | |
| | | | | | |

## 8. ACTIVIDADES EXTRACTIVAS Y DE ELABORACION

| Ud o algún miembro del hogar, realiza actividades de recolección o extracción:<br>Anote el código de la actividad | ¿Quién lo realiza?<br>Anote los números de orden de la pregunta 2.1 | Ingresos en la última temporada agrícola | Costos totales por esta actividad en el año |
|---|---|---|---|
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| | | | |
| | **TOTAL suma 8** | | |

| **TABLA COSTOS TOTALES**<br>Sume los costos de las preguntas: | | Costo ($) |
|---|---|---|
| | suma 3 | |
| | suma 5 | |
| | suma 6.1 | |
| | suma 6.2 | |
| | suma 6.3 | |
| | suma 7 | |
| | suma 8 | |
| | **TOTAL** | |

6

## 9. USO DE OTROS SERVICIOS FINANCIEROS

**Tipo de Cliente:** ______ **N° Correlativo:** ______

9.1 ¿Ud o algún miembro del hogar tiene o ha tenido alguno de los siguientes servicios financieros en los últimos 4 años, es decir desde mayo de 2000 a mayo de 2004 ?

| | | 1. Si<br>2. No | Con qué institución? | | | Desde qué año? | Por favor, indique quién es la persona del hogar que se relaciona con cada servicio. Incorpore el número de orden según pregunta N° 2.1. | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **CREDITOS Y FINANCIAMIENTO** | | 1 | 2 | 3 | | | | | | | |
| 1 | Crédito de corto plazo INDAP | | | | | | | | | | | |
| 2 | Crédito de largo plazo INDAP | | | | | | | | | | | |
| 3 | Crédito de corto plazo Banco Estado | | | | | | | | | | | |
| 4 | Crédito de largo plazo Banco Estado | | | | | | | | | | | |
| 5 | Crédito de corto plazo otros bancos | | | | | | | | | | | |
| 6 | Crédito de largo plazo otros bancos | | | | | | | | | | | |
| 7 | Crédito de corto plazo cooperativas de ahorro y crédito | | | | | | | | | | | |
| 8 | Crédito de largo plazo cooperativas de ahorro y crédito | | | | | | | | | | | |
| 9 | Anticipo de Proveedores | | | | | | | | | | | |
| 10 | Anticipo de compradores | | | | | | | | | | | |
| 11 | Anticipo de exportadores | | | | | | | | | | | |
| 12 | Crédito de exportadores | | | | | | | | | | | |
| 13 | Crédito de agroindustria | | | | | | | | | | | |
| | **OTROS SERVICIOS FINANCIEROS** | | | | | | | | | | | |
| 14 | Cuenta de Ahorro Tradicional | | | | | | | | | | | |
| 15 | Cuenta de Ahorro para la vivienda | | | | | | | | | | | |
| 16 | Cuenta Corriente con línea de crédito | | | | | | | | | | | |
| 17 | Cuenta Corriente sin línea de crédito | | | | | | | | | | | |
| 18 | Chequera electrónica | | | | | | | | | | | |
| 19 | Seguro Agrícola | | | | | | | | | | | |
| 20 | Seguro de salud /accidentes | | | | | | | | | | | |
| 21 | Seguro de Vida | | | | | | | | | | | |
| 22 | Seguro automotriz (no obligatorio) | | | | | | | | | | | |
| 23 | AFP | | | | | | | | | | | |
| 24 | INP | | | | | | | | | | | |
| 25 | Tarjeta de Red Banc | | | | | | | | | | | |
| 26 | Tarjeta de Casa Comercial Local | | | | | | | | | | | |
| 27 | Tarjeta de GrandesTiendas. | | | | | | | | | | | |
| 28 | Tarjetas de Crédito (Visa, Mastercard u otra) | | | | | | | | | | | |
| 29 | Leasing | | | | | | | | | | | |
| 30 | Leasback | | | | | | | | | | | |
| 31 | Factoring | | | | | | | | | | | |
| 32 | Warrant | | | | | | | | | | | |

7

## 9. USO DE OTROS SERVICIOS FINANCIEROS

**Tipo de Cliente:** ______ **Nº Correlativo:** ______

9.1 ¿Ud o algún miembro del hogar tiene o ha tenido alguno de los siguientes servicios financieros en los últimos 4 años, es decir desde mayo de 2000 a mayo de 2004 ?

| | OTROS SERVICIOS FINANCIEROS | 1. Si 2. No | Con qué institución? | | | Desde qué año? | Por favor, indique quién es la persona del hogar que se relaciona con cada servicio. Incorpore el número de orden según pregunta Nº 2.1. | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 1 | 2 | 3 | | | | | | | |
| 33 | Fondos Mutuos | | | | | | | | | | | |
| 34 | Acciones | | | | | | | | | | | |
| 35 | Depósito a plazos | | | | | | | | | | | |
| 36 | Otros | | | | | | | | | | | |

9.2 Sólo para aquellos individuos que tienen crédito en INDAP y no tienen NINGUNA RELACION con bancos o cooperativas de ahorro y crédito, preguntar:
¿Porqué no se vinculan o solicitan créditos en algún banco o cooperativa?

9.3 Sólo para aquellos hogares que NO tienen crédito en INDAP y tienen alguna relación con bancos o cooperativas de ahorro y crédito, preguntar: ¿Porqué no se vinculan o solicitan créditos en INDAP?

## 10. EVENTOS Y MOROSIDAD

10.1 Ud o algún miembro del hogar tiene un crédito o al menos una cuota de un crédito sin pagar?

**Si** ______ **¿Quién? Indique Nº Orden** ______ **Pase a 10.2** **Si** ______ **¿Quién? Indique Nº Orden** ______ **Pase a 10.2** **Si** ______ **¿Quién? Indique Nº Orden** ______ **Pase a 10.2**

**No** ______ **Pasar a 10.4**

10.2 En caso de que alguien haya dejado de pagar, por favor indique la fecha de no pago y con quien es la deuda ( Registre sólo la última vez)

**Fecha crédito moroso 1** ______/______ **mes / año**

**Con quién Indique** **1.**______________ **Pase a 10.3**

**Fecha crédito moroso 2** ______/______ **mes / año**

**Con quién Indique** **1.**______________ **Pase a 10.3**

**Fecha crédito moroso 3** ______/______ **mes / año**

**Con quién Indique** **1.**______________ **Pase a 10.3**

8

10.3 Por favor indique las razones por las que no pudo pagar el crédito

**Tipo de Cliente:** ______ **N° Correlativo:** ______

| | | 1. Si<br>2. No | Observación (si hay más de dos créditos morosos indique la razón de no pago de cada uno) | |
|---|---|---|---|---|
| 1 | Problemas de precio (disminución) | | | |
| 2 | Problemas de precio (mala proyección, sólo rubros nuevos) | | | |
| 3 | Problemas de producción: clima | | | |
| 4 | Problemas de producción: plaga o enfermedad | | | |
| 5 | Problemas de producción: semillas de mala calidad | | | |
| 6 | Problemas de comercialización: Incumplimientos de contrato | | | |
| 7 | Problemas de comercialización: Retraso de pagos | | | |
| 8 | Problemas de comercialización: Siniestro | | | |
| 9 | Problemas de comercialización: Robo/ Hurto | | | |
| 10 | Problemas de comercialización: Otros | | | |
| 11 | Crisis Familiar: enfermedad | | | |
| 12 | Crisis Familiar: Otros | | | |
| **13** | **Otros problemas (especificar)** | | | **Pasar a 10.5** |
| 14 | Otros problemas (especificar) | | | |

10.4 Ud o algún miembro del hogar ha tenido algunos de los siguientes problemas en los últimos años?

| | | 1. Si<br>2. No | ¿Qué ha hecho para pagar sus créditos o deudas? (Sólo si la respuesta es 1) |
|---|---|---|---|
| 1 | Problemas de precio (disminución drástica no esperada | | |
| 2 | Problemas de precio (mala proyección, sólo rubros nuevos | | |
| 3 | Problemas de producción: clima | | |
| 4 | Problemas de producción: plaga o enfermedad | | |
| 5 | Problemas de producción: semillas de mala calidad | | |
| 6 | Problemas de comercialización: Incumplimientos de contrato | | |
| 7 | Problemas de comercialización: Retraso de pagos | | |
| 8 | Problemas de comercialización: Siniestro | | |
| 9 | Problemas de comercialización: Robo/ Hurto | | |
| 10 | Problemas de comercialización: Otros | | |
| 11 | Crisis Familiar: enfermedad | | |
| 12 | Crisis Familiar: Otros | | |
| 13 | Otros problemas (especificar) | | |
| 14 | Otros problemas (especificar) | | |

10.5 PARA TODOS:
Ud. o alguién de su hogar ha sido sujeto de :

| | 1. Si<br>2. No | Cuándo?(año) (si es más de una vez anote los años de cada uno) | quién fue favorecido (N° de orden) | |
|---|---|---|---|---|
| Repactación de un crédito. | | | | |
| Condonación de un crédito. | | | | |

9

## 11. FUENTES DE FINANCIAMIENTO CAPITAL DE TRABAJO

Tipo de Cliente: ______ N° Correlativo: ______

A continuación queremos saber cómo ha financiado sus actividades productivas. Nos interesa saber la forma que Ud. se financia en el corto plazo, es decir, en la última temporada agrícola y también en el largo plazo, es decir en los últimos cuatro años, tanto para hacer inversiones que mejoraron su predio o negocio o como las inversiones para hacer cambios de rubros.

11.1 Señor(a): ¿Cómo financió sus necesidades de capital de trabajo en la última temporada, es decir entre Mayo de 2003 y Abril de 2004?

| | | 1. Si<br>2. No | Monto($) |
|---|---|---|---|
| A | Crédito | | |
| B | Anticipo proveedores (dinero o especies) | | |
| C | Anticipo compradores (dinero o especies) | | |
| D | Semillas propias | | |
| E | Ganancias temporada anterior | | |
| F | Ahorro monetario | | |
| G | Venta de animales y tierras | | |
| H | Remesas | | |
| I | Donaciones | | |
| J | Venta de tierra u otros activos fijos | | |
| K | Arriendo de tierras y mediería | | |
| L | Otros (especifique) | | |
| | **TOTAL (suma de ítemes A a L)** | | |

TABLA DE COSTOS Y CAPITAL DE TRABAJO

| Verifique que el Monto total del Cuadro 11.1 sea mayor o igual al total de la Tabla de Costos totales (pág. 6) | |
|---|---|
| | Monto($) |
| TOTAL TABLA COSTOS TOTALES (pág.6) | |
| TOTAL 11.1 | |
| DIFERENCIA (Siempre será cero o mayor.)<br>* Total 11.1 - Costos Totales | |

**11.2 Sólo si contesta que SÍ en 11.1 A (Crédito). Por favor, indique las fuentes de crédito para el capital de trabajo en la última temporada (Mayo 2003 a Abril de 2004)**

**11.2.1 Fuentes de crédito monetario**

| FUENTE (Ver código) | ¿Quién solicita el crédito? | Modalidad del crédito | Monto del crédito | Plazo del Crédito | Forma de Pago del Crédito | Nº de cuotas | Valor cuota | Tasa de interés | | Tipo de garantía:<br>1. Tierra<br>2. Vehículo<br>3. Aval<br>4. Maquinaria<br>5. Vivienda<br>6. FOGAPE (Ver manual)<br>7. Otro (especifique)<br>8. Sin Garantía | Situación actual del crédito:<br>1. Vigente<br>2. Moroso<br>3. Cancelado o Pagado<br>4. Castigado | Monto Mora | Tiempo en mora | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Ver Nº de Orden pregunta 2.1 | 1. Individual<br>2. Asociativo | ($) | (Meses) | 1. Cuotas parciales.<br>2. Pago a la cosecha | | | Valor<br>0<br>NS | Tipo<br>1. Mensual<br>2. Anual<br>3. NS | | | | Valor | Tipo<br>1. Días<br>2. Semanas<br>3. Meses<br>4 Años |
| | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | |

**Destino del crédito**

| | | |
|---|---|---|
| **Indicar uso de crédito por fuente** | FUENTE 1 | |
| | FUENTE 2 | |
| | FUENTE 3 | |
| | FUENTE 4 | |

10

11.2.2. Fuentes de crédito en especies

**Tipo de Cliente:** ______ **N° Correlativo:** ______

| Nombre de la fuente | ¿Quién solicita el crédito?<br><br>Ver Nº de Orden pregunta 2.1 | Nombre insumos | Precio | Cantidad | Unidad de medida<br><br>1.Kilos<br>2. Sacos (80kg)<br>3.Quintales<br>4.Toneladas<br>5.Unidades | Mes de operación | Mes de pago | Forma de pago<br><br>1. Dinero<br>2. Especies (producción) | Tipo de garantía:<br><br>1. Tierra<br>2. Vehículo<br>3. Aval<br>4. Maquinaria<br>5. Vivienda<br>6. FOGAPE (Ver manual)<br>7. Otro (especificque)<br>8. Sin Garantía | Monto de pago |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | |
| | | | | | | | | | | |
| | | | | | | | | | | |
| | | | | | | | | | | |
| | | | | | | | | | | |

## 12. FUENTES DE FINANCIAMIENTO DE INVERSIONES

12.1 En los últimos cuatro años (Mayo de 2000 a Abril de 2004), Ud o algún miembro del hogar realizó alguna inversión en activo fijo para MEJORAR o expandir sus rubros principales (se refiere a rubros que el agricultor mantiene por más de 4 años)

**Si** ________ **No** ________ **¿Quién pidió el crédito? (N° orden)** ______________

12.2. En los últimos cuatro años (Mayo de 2000 a Abril de 2004), Ud. o algún miembro del hogar realizó alguna inversión en activo fijo para CAMBIAR de rubro?.

**Si** ________ **No** ________ **¿Quién pidió el crédito? (N° orden)** ______________

12.3. Por favor indique la forma en que ha financiado estas inversiones

| Descripción | Tipo<br><br>1. Mejoras o expansión.<br>2. Cambio de Rubro | Año | Valor total | Fuente 1<br><br>Ver códigos derecha | Fuente 2<br><br>Ver códigos derecha | Fuente 3<br><br>Ver códigos derecha |
|---|---|---|---|---|---|---|
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |

| | |
|---|---|
| A | Crédito |
| B | Ganancias temporada anterio |
| C | Ahorro monetario |
| D | Venta de animales y tierras |
| E | Remesas |
| F | Donaciones |
| G | Venta de tierra u otros activos fijos |
| H | Arriendo de tierras y mediería |
| I | Otros (especifique) |

11

12.3.1 En caso de que haya financiado con crédito (sólo si contesta 12.3 A), por favor indique las características del crédito **Tipo de Cliente:** ______ **N° Correlativo:** ______

| Fuente (Ver codigos) | Tipo<br>1. Mejoras o expansión<br>2. Cambio de rubro<br>3. Ambas | ¿Quién solicita el crédito?<br>Ver Nº de Orden pregunta 2.1 | Modalidad del crédito<br>1. Individual<br>2. Asociativo | Monto del crédito<br>($) | Plazo del Crédito<br>(Meses) | Forma de Pago del Crédito<br>1. Cuotas parciales.<br>2. Pago a la cosecha | Valor cuota | Nº de cuotas | Tasa de interés | | Tipo de garantía:<br>1. Tierra<br>2. Vehículo<br>3. Aval<br>4. Maquinaria<br>5. Vivienda<br>6. Otro (especifique)<br>7. Sin Garantía | Situación actual del crédito:<br>1. Vigente<br>2. Moroso<br>3. Cancelado o Pagado<br>4. Castigado | Monto Mora | Tiempo en mora | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | Valor 0 NS | Tipo<br>1. Mensual<br>2. Anual<br>3. NS | | | | Valor | Tipo<br>1. Días<br>2. Semanas<br>3. Meses<br>4. Años |
| | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |

## 13. EXPECTATIVAS

| 13.1 | 1. Muy alto | 2. Alto | 3. Igual | 4. Bajo | 5. Muy bajo |
|---|---|---|---|---|---|
| En relación al año 2000, Ud. considera que su Ingreso Familiar por la agricultura es: | | | | | |
| En relación al año 2000, Ud considera que su Ingreso Familiar por el trabajo apatronado (asalariado) | | | | | |
| En relación al año 2000, Ud considera que su Ingreso por actividades no agrícolas del hogar es: | | | | | |
| En relación al año 2000, Ud considera que su Ingreso por dinero enviado por familiares (remesas) es: | | | | | |
| En relación al año 2000, Ud considera que su Ingresos por subsidios y jubilaciones es: | | | | | |
| En relación al año 2000, Ud considera que su los precios de los productos es: | | | | | |
| En relación al año 2000, Ud considera que la cantidad de compradores es: | | | | | |
| | | | | | |

13.2. En los próximos 10 años ¿de dónde cree Ud. que obtendrá sus ingresos para vivir? Seleccione 3 alternativas en orden de importancia:

| | |
|---|---|
| Venta de tierra | |
| Producción agrícola | |
| Trabajo asalariado o apatronado. | |
| Producción propia agrícola | |
| Subsidios y jubilaciones | |
| Dinero enviado por familiares | |
| | |

13.3 ACTUALMENTE Ud. o algún miembro del hogar tiene algunos de las siguientes necesidades?

| | 1.Sí<br>2.No | Rango de necesidad ($) | | Tiempo | ¿Quién cree que puede brindar este servicio? | | |
|---|---|---|---|---|---|---|---|
| | | Máximo | Mínimo | Tipo<br>1. Mensual<br>2. Anual | 1 | 2 | 3 |
| 1. Crédito para capital de trabajo | | | | | | | |
| 2. Crédito para inversiones | | | | | | | |
| 3. Crédito para comprar bienes para el hogar | | | | | | | |
| 4. Seguros para la producción | | | | | | | |
| 5. Para ahorrar dinero | | | | | | | |
| 6. Para invertir su dinero | | | | | | | |
| 7. Crédito para estudiar | | | | | | | |

12

## 14. SATISFACCION

Tipo de Cliente: ______ N° Correlativo: ______

14.1 En los últimos créditos que Ud. o algún miembro del hogar ha pedido o solicitado un crédito , por favor indique el grado de satisfacción en los siguientes aspectos:

Por favor indique los rangos de satisfacción. Señale una nota de 1 a 7, donde:
1: Es muy mala y 7: Muy bueno

**Nota: Solo cliente INDAP. Para controles si el entrevistado ha solicitado un crédito**

| PROVEEDOR | Atención al cliente | Facilidad para obtener | Forma de pago | Montos prestados | Acceso a oficinas | Información disponible |
|---|---|---|---|---|---|---|
| | | | | | | |
| INDAP | | | | | | |
| BANCO DE ESTADO | | | | | | |
| OTRO BANCO (especifique) | | | | | | |
| | | | | | | |
| FINANCIERA (especifique) | | | | | | |
| | | | | | | |
| CASA COMERCIAL (especifique) | | | | | | |
| | | | | | | |
| FAMILIAR | | | | | | |
| PRESTAMISTA | | | | | | |
| | | | | | | |

15. Ud tiene al día el pago de las siguientes servicios:

| | | | | | | |
|---|---|---|---|---|---|---|
| Teléfonos | si | ☐ | no | ☐ | No tiene | ☐ |
| Luz | si | ☐ | no | ☐ | No tiene | ☐ |
| Agua | si | ☐ | no | ☐ | No tiene | ☐ |
| Casas comerciales | si | ☐ | no | ☐ | No tiene | ☐ |

**SEÑOR(A): HEMOS TERMINADO. MUCHAS GRACIAS POR SU COLABORACIÓN Y AYUDA.**

16. ATENCIÓN ENCUESTADOR: A continuación le dejamos un espacio para anotar algunos aspectos de interés que Ud. ha visualizado en el predio, hogar o con respecto a la persona entrevistada. Por favor continue con la entrevista y al final de ella, complete los ítemes que estamos solicitando. Se trata de recibir su opinión sobre los siguientes aspectos que deben ser indagados por Ud:

| | | | | | | |
|---|---|---|---|---|---|---|
| Orden general del predio | Bueno | ☐ | Regular | ☐ | Malo | ☐ |
| Orden general de la casa habitación | Bueno | ☐ | Regular | ☐ | Malo | ☐ |
| Orden personal | Bueno | ☐ | Regular | ☐ | Malo | ☐ |

OBSERVACIONES:

13

# Appendix 2

## Estimations for Specialized Crop Production with alternative estimated family labor forces

---- Sfa ----
The estimation sample is: 1 - 342
The dependent variable is: LYM

| | Coefficient | Std.Error | robust-SE | t-value | t-prob |
|---|---|---|---|---|---|
| Constant | -0.106789 | 0.1605 | 0.1644 | -0.650 | 0.516 |
| Lam | 0.334082 | 0.1018 | 0.1162 | 2.88 | 0.004 |
| Lwcm | 0.569556 | 0.1040 | 0.09729 | 5.85 | 0.000 |
| **Ltam** | **0.365894** | **0.1530** | **0.1334** | **2.74** | **0.006** |
| PIA | 2.12827 | 0.5683 | 0.5455 | 3.90 | 0.000 |
| DL3 | -0.232518 | 0.08106 | 0.08454 | -2.75 | 0.006 |
| DL4 | -0.494026 | 0.1093 | 0.1119 | -4.42 | 0.000 |
| DL5 | -0.382536 | 0.1679 | 0.1854 | -2.06 | 0.040 |
| .5*Lam^2 | -0.0950163 | 0.06470 | 0.06836 | -1.39 | 0.166 |
| .5*Lwcm^2 | -0.0376718 | 0.05050 | 0.04983 | -0.756 | 0.450 |
| .5*Ltam^2 | -0.104157 | 0.1496 | 0.1105 | -0.942 | 0.347 |
| .5*PIA^2 | -3.52445 | 1.040 | 0.9606 | -3.67 | 0.000 |
| Lam*Lwcm | 0.105761 | 0.04519 | 0.04814 | 2.20 | 0.029 |
| Lam*Ltam | -0.0146580 | 0.09086 | 0.08097 | -0.181 | 0.856 |
| Lam*PIA | -0.0602729 | 0.09932 | 0.1209 | -0.498 | 0.619 |
| Lwcm*Ltam | 0.139460 | 0.06789 | 0.05394 | 2.59 | 0.010 |
| Lwcm*PIA | 0.177708 | 0.08553 | 0.08227 | 2.16 | 0.032 |
| Ltam*PIA | -0.330413 | 0.1634 | 0.1432 | -2.31 | 0.022 |
| ln{\sigma_v} | -0.666436 | 0.04091 | 0.04674 | -14.3 | 0.000 |
| Constant | 3.36503 | 1.293 | 0.9897 | 3.40 | 0.001 |
| Lam | 0.523187 | 0.2154 | 0.1897 | 2.76 | 0.006 |
| Lwcm | 0.761701 | 0.2117 | 0.2012 | 3.79 | 0.000 |
| Ltam | 0.523007 | 0.3081 | 0.2367 | 2.21 | 0.028 |
| Dindap | -0.332888 | 0.3119 | 0.2523 | -1.32 | 0.188 |
| Dmanag | -0.0734015 | 0.3011 | 0.2308 | -0.318 | 0.751 |
| Dex | 1.09348 | 0.4784 | 0.3987 | 2.74 | 0.006 |
| Sha | -7.13180 | 1.404 | 0.9562 | -7.46 | 0.000 |
| Acc | -0.107182 | 0.07770 | 0.04722 | -2.27 | 0.024 |
| FS | -0.260360 | 0.1281 | 0.1021 | -2.55 | 0.011 |
| Age | 0.0128415 | 0.01069 | 0.007147 | 1.80 | 0.073 |
| Edu | -0.102596 | 0.05580 | 0.03805 | -2.70 | 0.007 |
| Cred | -0.589365 | 0.2275 | 0.1570 | -3.75 | 0.000 |
| Dcc | 0.811282 | 0.3168 | 0.2563 | 3.17 | 0.002 |

| | | | |
|---|---|---|---|
| log-likelihood | -275.505637 | | |
| no. of observations | 342 | no. of parameters | 33 |
| AIC.T | 617.011275 | AIC | 1.80412653 |
| mean(Lym) | -1.10134 | var(Lym) | 1.99399 |
| \gamma: | 0.5999 | VAR(u)/VAR(total) | 0.3527 |
| Test of one-sided err | 69.422 | mixed Chi^2 !! | |

```
---- Sfa ----
The estimation sample is:  1 - 342
The dependent variable is: LYM
```

| | Coefficient | Std.Error | robust-SE | t-value | t-prob |
|---|---|---|---|---|---|
| Constant | -0.0992304 | 0.1604 | 0.1627 | -0.610 | 0.542 |
| Lam | 0.332521 | 0.1018 | 0.1161 | 2.86 | 0.004 |
| Lwcm | 0.582587 | 0.1032 | 0.09544 | 6.10 | 0.000 |
| **LTbm** | **0.330705** | **0.1404** | **0.1138** | **2.91** | **0.004** |
| PIA | 2.13354 | 0.5659 | 0.5419 | 3.94 | 0.000 |
| DL3 | -0.233873 | 0.08085 | 0.08476 | -2.76 | 0.006 |
| DL4 | -0.497606 | 0.1092 | 0.1124 | -4.43 | 0.000 |
| DL5 | -0.367019 | 0.1669 | 0.1895 | -1.94 | 0.054 |
| .5*Lam^2 | -0.0932621 | 0.06461 | 0.06748 | -1.38 | 0.168 |
| .5*Lwcm^2 | -0.0311250 | 0.04973 | 0.04852 | -0.641 | 0.522 |
| .5*LTbm^2 | -0.0827725 | 0.1142 | 0.08691 | -0.952 | 0.342 |
| .5*PIA^2 | -3.55139 | 1.036 | 0.9541 | -3.72 | 0.000 |
| Lam*Lwcm | 0.102337 | 0.04505 | 0.04750 | 2.15 | 0.032 |
| Lam*LTbm | -0.0374523 | 0.08485 | 0.07753 | -0.483 | 0.629 |
| Lam*PIA | -0.0630166 | 0.09896 | 0.1200 | -0.525 | 0.600 |
| Lwcm*LTbm | 0.141262 | 0.06177 | 0.04654 | 3.04 | 0.003 |
| Lwcm*PIA | 0.167386 | 0.08525 | 0.08129 | 2.06 | 0.040 |
| LTbm*PIA | -0.304096 | 0.1436 | 0.1143 | -2.66 | 0.008 |
| ln{\sigma_v} | -0.668945 | 0.04082 | 0.04684 | -14.3 | 0.000 |
| Constant | 3.36752 | 1.274 | 0.9631 | 3.50 | 0.001 |
| Lam | 0.525180 | 0.2171 | 0.1926 | 2.73 | 0.007 |
| Lwcm | 0.763504 | 0.2110 | 0.1971 | 3.87 | 0.000 |
| LTbm | 0.529028 | 0.2751 | 0.1922 | 2.75 | 0.006 |
| Dindap | -0.365013 | 0.3167 | 0.2600 | -1.40 | 0.161 |
| Dmanag | -0.0496528 | 0.3025 | 0.2282 | -0.218 | 0.828 |
| Dex | 1.12057 | 0.4842 | 0.4154 | 2.70 | 0.007 |
| Sha | -7.21029 | 1.401 | 0.9582 | -7.52 | 0.000 |
| Dcc | 0.813167 | 0.3180 | 0.2570 | 3.16 | 0.002 |
| Cred | -0.599480 | 0.2286 | 0.1567 | -3.83 | 0.000 |
| Acc | -0.109781 | 0.07704 | 0.04588 | -2.39 | 0.017 |
| FS | -0.258636 | 0.1246 | 0.09641 | -2.68 | 0.008 |
| Age | 0.0135123 | 0.01073 | 0.007022 | 1.92 | 0.055 |
| Edu | -0.102716 | 0.05619 | 0.03855 | -2.66 | 0.008 |

```
log-likelihood     -274.605802
no. of observations        342  no. of parameters          33
AIC.T               615.211604  AIC                1.79886434
mean(Lym)             -1.10134  var(Lym)              1.99399
\gamma:                 0.6099  VAR(u)/VAR(total)      0.3623
Test of one-sided err   72.967  mixed Chi^2 !!
```

```
---- Sfa ----
The estimation sample is:  1 - 342
The dependent variable is: LYM
```

| | Coefficient | Std.Error | robust-SE | t-value | t-prob |
|---|---|---|---|---|---|
| Constant | -0.107041 | 0.1607 | 0.1637 | -0.654 | 0.514 |
| Lam | 0.339499 | 0.1016 | 0.1155 | 2.94 | 0.004 |
| Lwcm | 0.566263 | 0.1045 | 0.09847 | 5.75 | 0.000 |
| **LTcm** | **0.389544** | **0.1519** | **0.1299** | **3.00** | **0.003** |
| PIA | 2.07199 | 0.5681 | 0.5428 | 3.82 | 0.000 |
| DL3 | -0.230863 | 0.08099 | 0.08470 | -2.73 | 0.007 |
| DL4 | -0.493358 | 0.1092 | 0.1122 | -4.40 | 0.000 |
| DL5 | -0.395229 | 0.1694 | 0.1859 | -2.13 | 0.034 |
| .5*Lam^2 | -0.0927286 | 0.06416 | 0.06712 | -1.38 | 0.168 |
| .5*Lwcm^2 | -0.0396722 | 0.05047 | 0.05027 | -0.789 | 0.431 |
| .5*LTcm^2 | -0.0161887 | 0.1195 | 0.09082 | -0.178 | 0.859 |
| .5*PIA^2 | -3.42690 | 1.037 | 0.9545 | -3.59 | 0.000 |
| Lam*Lwcm | 0.105366 | 0.04487 | 0.04792 | 2.20 | 0.029 |
| Lam*LTcm | -0.0281667 | 0.08538 | 0.07590 | -0.371 | 0.711 |
| Lam*PIA | -0.0671137 | 0.09890 | 0.1206 | -0.557 | 0.578 |
| Lwcm*LTcm | 0.142308 | 0.06666 | 0.05327 | 2.67 | 0.008 |
| Lwcm*PIA | 0.177463 | 0.08615 | 0.08330 | 2.13 | 0.034 |
| LTcm*PIA | -0.351902 | 0.1631 | 0.1424 | -2.47 | 0.014 |
| ln{\sigma_v} | -0.668737 | 0.04096 | 0.04684 | -14.3 | 0.000 |
| Constant | 3.33280 | 1.322 | 1.025 | 3.25 | 0.001 |
| Lam | 0.556818 | 0.2175 | 0.1917 | 2.90 | 0.004 |
| Lwcm | 0.741333 | 0.2088 | 0.1999 | 3.71 | 0.000 |
| LTcm | 0.475224 | 0.2840 | 0.2171 | 2.19 | 0.029 |
| Dindap | -0.346172 | 0.3055 | 0.2412 | -1.44 | 0.152 |
| Dmanag | -0.0813900 | 0.3020 | 0.2313 | -0.352 | 0.725 |
| Dex | 1.11229 | 0.4746 | 0.3885 | 2.86 | 0.004 |
| Sha | -7.23087 | 1.406 | 0.9738 | -7.43 | 0.000 |
| Cred | -0.600382 | 0.2253 | 0.1527 | -3.93 | 0.000 |
| Dcc | 0.790855 | 0.3088 | 0.2494 | 3.17 | 0.002 |
| Acc | -0.117038 | 0.08235 | 0.05324 | -2.20 | 0.029 |
| FS | -0.257138 | 0.1305 | 0.1060 | -2.43 | 0.016 |
| Age | 0.0146524 | 0.01065 | 0.006975 | 2.10 | 0.036 |
| Edu | -0.102893 | 0.05546 | 0.03825 | -2.69 | 0.008 |

```
log-likelihood     -275.260095
no. of observations        342  no. of parameters          33
AIC.T               616.520189  AIC                1.80269061
mean(Lym)             -1.10134  var(Lym)              1.99399
\gamma:                 0.6045  VAR(u)/VAR(total)      0.3571
Test of one-sided err   71.419  mixed Chi^2 !!
```

---- Sfa ----
The estimation sample is: 1 - 342
The dependent variable is: LYM

| | Coefficient | Std.Error | robust-SE | t-value | t-prob |
|---|---|---|---|---|---|
| Constant | -0.107219 | 0.1607 | 0.1639 | -0.654 | 0.513 |
| Lam | 0.334273 | 0.1018 | 0.1157 | 2.89 | 0.004 |
| Lwcm | 0.572227 | 0.1041 | 0.09740 | 5.88 | 0.000 |
| **LTdm** | **0.336314** | **0.1522** | **0.1278** | **2.63** | **0.009** |
| PIA | 2.14080 | 0.5675 | 0.5451 | 3.93 | 0.000 |
| DL3 | -0.232809 | 0.08099 | 0.08476 | -2.75 | 0.006 |
| DL4 | -0.494181 | 0.1089 | 0.1115 | -4.43 | 0.000 |
| DL5 | -0.380153 | 0.1677 | 0.1889 | -2.01 | 0.045 |
| .5*Lam^2 | -0.0924630 | 0.06480 | 0.06843 | -1.35 | 0.178 |
| .5*Lwcm^2 | -0.0366699 | 0.05037 | 0.04966 | -0.738 | 0.461 |
| .5*LTdm^2 | -0.118834 | 0.1122 | 0.07779 | -1.53 | 0.128 |
| .5*PIA^2 | -3.54835 | 1.037 | 0.9574 | -3.71 | 0.000 |
| Lam*Lwcm | 0.104693 | 0.04533 | 0.04834 | 2.17 | 0.031 |
| Lam*LTdm | -0.0214159 | 0.08791 | 0.07759 | -0.276 | 0.783 |
| Lam*PIA | -0.0594820 | 0.09891 | 0.1197 | -0.497 | 0.620 |
| Lwcm*LTdm | 0.143082 | 0.06794 | 0.05444 | 2.63 | 0.009 |
| Lwcm*PIA | 0.172465 | 0.08574 | 0.08230 | 2.10 | 0.037 |
| LTdm*PIA | -0.303488 | 0.1520 | 0.1200 | -2.53 | 0.012 |
| ln{\sigma_v} | -0.667092 | 0.04085 | 0.04679 | -14.3 | 0.000 |
| Constant | 3.40728 | 1.287 | 0.9748 | 3.50 | 0.001 |
| Lam | 0.516370 | 0.2150 | 0.1905 | 2.71 | 0.007 |
| Lwcm | 0.766810 | 0.2115 | 0.2006 | 3.82 | 0.000 |
| LTdm | 0.567063 | 0.2943 | 0.2126 | 2.67 | 0.008 |
| Dindap | -0.346235 | 0.3175 | 0.2619 | -1.32 | 0.187 |
| Dmanag | -0.0717346 | 0.3021 | 0.2287 | -0.314 | 0.754 |
| Dex | 1.11403 | 0.4879 | 0.4251 | 2.62 | 0.009 |
| Sha | -7.21226 | 1.406 | 0.9590 | -7.52 | 0.000 |
| Cred | -0.594407 | 0.2304 | 0.1610 | -3.69 | 0.000 |
| Dcc | 0.807477 | 0.3176 | 0.2579 | 3.13 | 0.002 |
| Acc | -0.109026 | 0.07715 | 0.04597 | -2.37 | 0.018 |
| FS | -0.264235 | 0.1251 | 0.09671 | -2.73 | 0.007 |
| Age | 0.0131269 | 0.01075 | 0.007102 | 1.85 | 0.066 |
| Edu | -0.101870 | 0.05603 | 0.03821 | -2.67 | 0.008 |

| | | | |
|---|---|---|---|
| log-likelihood | -275.132934 | | |
| no. of observations | 342 | no. of parameters | 33 |
| AIC.T | 616.265867 | AIC | 1.80194698 |
| mean(Lym) | -1.10134 | var(Lym) | 1.99399 |
| \gamma: | 0.6064 | VAR(u)/VAR(total) | 0.3589 |
| Test of one-sided err | 71.311 | mixed Chi^2 !! | |

---- Sfa ----
The estimation sample is: 1 - 342
The dependent variable is: LYM

| | Coefficient | Std.Error | robust-SE | t-value | t-prob |
|---|---|---|---|---|---|
| Constant | -0.105389 | 0.1601 | 0.1631 | -0.646 | 0.519 |
| Lam | 0.330680 | 0.1020 | 0.1167 | 2.83 | 0.005 |
| Lwcm | 0.575728 | 0.1036 | 0.09727 | 5.92 | 0.000 |
| **LTem** | **0.347072** | **0.1510** | **0.1278** | **2.72** | **0.007** |
| PIA | 2.11556 | 0.5664 | 0.5408 | 3.91 | 0.000 |
| DL3 | -0.231154 | 0.08080 | 0.08472 | -2.73 | 0.007 |
| DL4 | -0.495269 | 0.1090 | 0.1118 | -4.43 | 0.000 |
| DL5 | -0.380379 | 0.1676 | 0.1888 | -2.01 | 0.045 |
| .5*Lam^2 | -0.0937480 | 0.06476 | 0.06855 | -1.37 | 0.172 |
| .5*Lwcm^2 | -0.0371383 | 0.05019 | 0.05007 | -0.742 | 0.459 |
| .5*LTem^2 | -0.0924021 | 0.1031 | 0.07542 | -1.23 | 0.221 |
| .5*PIA^2 | -3.51196 | 1.034 | 0.9479 | -3.71 | 0.000 |
| Lam*Lwcm | 0.104335 | 0.04525 | 0.04844 | 2.15 | 0.032 |
| Lam*LTem | -0.0218286 | 0.08459 | 0.07410 | -0.295 | 0.769 |
| Lam*PIA | -0.0547590 | 0.09933 | 0.1202 | -0.455 | 0.649 |
| Lwcm*LTem | 0.155526 | 0.06487 | 0.05096 | 3.05 | 0.002 |
| Lwcm*PIA | 0.166337 | 0.08566 | 0.08220 | 2.02 | 0.044 |
| LTem*PIA | -0.312225 | 0.1467 | 0.1169 | -2.67 | 0.008 |
| ln{\sigma_v} | -0.669782 | 0.04088 | 0.04695 | -14.3 | 0.000 |
| Constant | 3.40879 | 1.279 | 0.9619 | 3.54 | 0.000 |
| Lam | 0.520926 | 0.2133 | 0.1873 | 2.78 | 0.006 |
| Lwcm | 0.757893 | 0.2092 | 0.1974 | 3.84 | 0.000 |
| LTem | 0.538373 | 0.2765 | 0.2007 | 2.68 | 0.008 |
| Dindap | -0.371494 | 0.3165 | 0.2615 | -1.42 | 0.156 |
| Dmanag | -0.0639676 | 0.3009 | 0.2253 | -0.284 | 0.777 |
| Dex | 1.14608 | 0.4891 | 0.4288 | 2.67 | 0.008 |
| Sha | -7.24875 | 1.406 | 0.9612 | -7.54 | 0.000 |
| Cred | -0.607775 | 0.2295 | 0.1590 | -3.82 | 0.000 |
| Dcc | 0.809231 | 0.3151 | 0.2535 | 3.19 | 0.002 |
| Acc | -0.110641 | 0.07800 | 0.04629 | -2.39 | 0.017 |
| FS | -0.262707 | 0.1234 | 0.09334 | -2.81 | 0.005 |
| Age | 0.0134952 | 0.01064 | 0.006950 | 1.94 | 0.053 |
| Edu | -0.102941 | 0.05557 | 0.03788 | -2.72 | 0.007 |

| | | | |
|---|---|---|---|
| log-likelihood | -274.364081 | | |
| no. of observations | 342 | no. of parameters | 33 |
| AIC.T | 614.728163 | AIC | 1.79745077 |
| mean(Lym) | -1.10134 | var(Lym) | 1.99399 |
| \gamma: | 0.6008 | VAR(u)/VAR(total) | 0.3535 |
| Test of one-sided err | 72.023 | mixed Chi^2 !! | |

# Appendix 3
# Estimations for Specialized Livestock Production with alternative estimated family labor forces

---- Sfa ----
The estimation sample is: 1 - 109
The dependent variable is: Lym (DataEXTRCatte.in7)
0

| | Coefficient | Std.Error | robust-SE | t-value | t-prob |
|---|---|---|---|---|---|
| Constant | 0.123587 | 0.1026 | 0.08655 | 1.43 | 0.157 |
| Lwcm | 0.518691 | 0.08653 | 0.07761 | 6.68 | 0.000 |
| Lavm | 0.858480 | 0.1297 | 0.1266 | 6.78 | 0.000 |
| PIA | -0.170618 | 0.6664 | 0.9859 | -0.173 | 0.863 |
| .5*Lwcm^2 | 0.0909962 | 0.06030 | 0.04635 | 1.96 | 0.053 |
| .5*Lavm^2 | 0.297580 | 0.1321 | 0.1123 | 2.65 | 0.010 |
| .5*PIA^2 | 0.559198 | 1.359 | 2.034 | 0.275 | 0.784 |
| Lwcm*Lavm | 0.0468300 | 0.07406 | 0.05733 | 0.817 | 0.416 |
| Lwcm*PIA | 0.163096 | 0.09821 | 0.08160 | 2.00 | 0.049 |
| Lavm*PIA | -0.249278 | 0.2071 | 0.2147 | -1.16 | 0.249 |
| ln{\sigma_v} | -1.00981 | 0.08698 | 0.07938 | -12.7 | 0.000 |
| Constant | 1.58414 | 1.167 | 0.9624 | 1.65 | 0.103 |
| Lwcm | 0.389989 | 0.1951 | 0.1643 | 2.37 | 0.020 |
| Lavm | 0.776408 | 0.3701 | 0.2618 | 2.97 | 0.004 |
| Dindap | -0.739433 | 0.3561 | 0.2492 | -2.97 | 0.004 |
| Dmanag | 1.01978 | 0.4036 | 0.2665 | 3.83 | 0.000 |
| DGl | -0.179309 | 0.3412 | 0.2587 | -0.693 | 0.490 |
| Sha | -2.06371 | 0.9005 | 0.7622 | -2.71 | 0.008 |
| Cred | 0.239591 | 0.1929 | 0.1170 | 2.05 | 0.044 |
| Dcc | -1.14244 | 0.4263 | 0.3261 | -3.50 | 0.001 |
| Acc | -0.0528336 | 0.04239 | 0.03517 | -1.50 | 0.137 |
| FS | 0.0858178 | 0.1311 | 0.1307 | 0.657 | 0.513 |
| Age | -0.0233257 | 0.01505 | 0.01214 | -1.92 | 0.058 |
| Edu | -0.0250684 | 0.03300 | 0.02526 | -0.992 | 0.324 |

| | | | |
|---|---|---|---|
| log-likelihood | -65.9672979 | | |
| no. of observations | 109 | no. of parameters | 24 |
| AIC.T | 179.934596 | AIC | 1.65077611 |
| mean(Lym) | -0.674068 | var(Lym) | 1.10892 |
| \gamma: | 0.8043 | VAR(u)/VAR(total) | 0.599 |
| Test of one-sided err | 43.247 | mixed Chi^2 !! | |

---- Sfa ----
The estimation sample is: 1 - 109
The dependent variable is: LYM

| | **Coefficient** | **Std.Error** | **robust-SE** | **t-value** | **t-prob** |
|---|---|---|---|---|---|
| Constant | 0.132344 | 0.2527 | 0.3456 | 0.383 | 0.703 |
| Lam | 0.0673104 | 0.1172 | 0.1246 | 0.540 | 0.591 |
| Lwcm | 0.534548 | 0.09298 | 0.06371 | 8.39 | 0.000 |
| Ltam | 0.193500 | 0.2126 | 0.2681 | 0.722 | 0.473 |
| Lavm | 0.779229 | 0.1780 | 0.2278 | 3.42 | 0.001 |
| PIA | -0.851856 | 0.9051 | 1.798 | -0.474 | 0.637 |
| DL3 | 0.207022 | 0.2435 | 0.2882 | 0.718 | 0.475 |
| DL4 | 0.0745486 | 0.1855 | 0.1833 | 0.407 | 0.685 |
| DL5 | -0.000476077 | 0.2012 | 0.1910 | -0.00249 | 0.998 |
| .5*Lam^2 | -0.00555474 | 0.09146 | 0.09924 | -0.0560 | 0.956 |
| .5*Lwcm^2 | 0.0757507 | 0.06281 | 0.04051 | 1.87 | 0.066 |
| .5*Ltam^2 | 0.0481655 | 0.1669 | 0.1425 | 0.338 | 0.736 |
| .5*Lavm^2 | 0.271182 | 0.1424 | 0.1215 | 2.23 | 0.029 |
| .5*PIA^2 | 2.56471 | 2.068 | 4.245 | 0.604 | 0.548 |
| Lam*Lwcm | 0.0705039 | 0.05422 | 0.04900 | 1.44 | 0.155 |
| Lam*Ltam | -0.146615 | 0.1074 | 0.1119 | -1.31 | 0.194 |
| Lam*Lavm | -0.0424294 | 0.07010 | 0.07496 | -0.566 | 0.573 |
| Lam*PIA | 0.317574 | 0.1970 | 0.1827 | 1.74 | 0.087 |
| Lwcm*Ltam | 0.103200 | 0.1144 | 0.1015 | 1.02 | 0.313 |
| Lwcm*Lavm | 0.0332462 | 0.08721 | 0.08643 | 0.385 | 0.702 |
| Lwcm*PIA | 0.157656 | 0.1348 | 0.1066 | 1.48 | 0.144 |
| Ltam*Lavm | -0.0428867 | 0.1140 | 0.1169 | -0.367 | 0.715 |
| Ltam*PIA | -0.171093 | 0.4201 | 0.4511 | -0.379 | 0.706 |
| Lavm*PIA | -0.501374 | 0.2581 | 0.2641 | -1.90 | 0.062 |
| ln{\sigma_v} | -1.05221 | 0.09948 | 0.1124 | -9.36 | 0.000 |
| Constant | 1.86524 | 1.539 | 1.367 | 1.36 | 0.177 |
| Lam | 0.244104 | 0.3357 | 0.4839 | 0.504 | 0.616 |
| Lwcm | 0.370198 | 0.2687 | 0.3301 | 1.12 | 0.266 |
| Ltam | 0.410452 | 0.5157 | 0.6010 | 0.683 | 0.497 |
| Lavm | 0.712790 | 0.7670 | 1.397 | 0.510 | 0.611 |
| Dindap | -0.839307 | 0.4122 | 0.3361 | -2.50 | 0.015 |
| Dmanag | 1.02006 | 0.4508 | 0.3055 | 3.34 | 0.001 |
| DGl | -0.255936 | 0.4551 | 0.5308 | -0.482 | 0.631 |
| Sha | -1.96125 | 1.342 | 2.301 | -0.852 | 0.397 |
| Cred | 0.206587 | 0.2427 | 0.2312 | 0.893 | 0.375 |
| Dcc | -0.998026 | 0.4954 | 0.5798 | -1.72 | 0.090 |
| Acc | -0.0510736 | 0.05308 | 0.07009 | -0.729 | 0.469 |
| FS | 0.0270621 | 0.1869 | 0.1837 | 0.147 | 0.883 |
| Age | -0.0255126 | 0.01753 | 0.01584 | -1.61 | 0.112 |
| Edu | -0.0145025 | 0.03884 | 0.04684 | -0.310 | 0.758 |

| | | | |
|---|---|---|---|
| log-likelihood | -59.7497808 | | |
| no. of observations | 109 | no. of parameters | 40 |
| AIC.T | 199.499562 | AIC | 1.83027121 |
| mean(Lym) | -0.674068 | var(Lym) | 1.10892 |
| \gamma: | 0.8208 | VAR(u)/VAR(total) | 0.6247 |
| Test of one-sided err | 38.851 | mixed Chi^2 !! | |

---- Sfa ----
The estimation sample is: 1 - 109
The dependent variable is: LYM

| | **Coefficient** | **Std.Error** | **robust-SE** | **t-value** | **t-prob** |
|---|---|---|---|---|---|
| Constant | 0.133475 | 0.2379 | 0.2558 | 0.522 | 0.604 |
| Lam | 0.0680624 | 0.1143 | 0.1132 | 0.601 | 0.550 |
| Lwcm | 0.538480 | 0.09487 | 0.06488 | 8.30 | 0.000 |
| Lavm | 0.768994 | 0.1760 | 0.2031 | 3.79 | 0.000 |
| LTbm | 0.162947 | 0.2185 | 0.2416 | 0.674 | 0.502 |
| PIA | -0.895121 | 0.8305 | 1.433 | -0.625 | 0.534 |
| DL3 | 0.195525 | 0.2347 | 0.2665 | 0.734 | 0.466 |
| DL4 | 0.0679568 | 0.1878 | 0.1830 | 0.371 | 0.712 |
| DL5 | -0.00789022 | 0.2010 | 0.1878 | -0.0420 | 0.967 |
| .5*Lam^2 | -0.00991684 | 0.09172 | 0.09487 | -0.105 | 0.917 |
| .5*Lwcm^2 | 0.0765042 | 0.06495 | 0.04136 | 1.85 | 0.069 |
| .5*Lavm^2 | 0.271547 | 0.1414 | 0.1149 | 2.36 | 0.021 |
| .5*LTbm^2 | 0.00556508 | 0.1528 | 0.1342 | 0.0415 | 0.967 |
| .5*PIA^2 | 2.63862 | 1.870 | 3.301 | 0.799 | 0.427 |
| Lam*Lwcm | 0.0734057 | 0.05496 | 0.05077 | 1.45 | 0.153 |
| Lam*Lavm | -0.0436296 | 0.07062 | 0.07484 | -0.583 | 0.562 |
| Lam*LTbm | -0.146234 | 0.1072 | 0.1044 | -1.40 | 0.166 |
| Lam*PIA | 0.297796 | 0.1976 | 0.1883 | 1.58 | 0.118 |
| Lwcm*Lavm | 0.0307746 | 0.08906 | 0.08136 | 0.378 | 0.706 |
| Lwcm*LTbm | 0.0998216 | 0.1144 | 0.1021 | 0.978 | 0.331 |
| Lwcm*PIA | 0.164451 | 0.1338 | 0.1011 | 1.63 | 0.109 |
| Lavm*LTbm | -0.0392463 | 0.1107 | 0.1140 | -0.344 | 0.732 |
| Lavm*PIA | -0.482084 | 0.2546 | 0.2565 | -1.88 | 0.064 |
| LTbm*PIA | -0.163954 | 0.3970 | 0.3919 | -0.418 | 0.677 |
| ln{\sigma_v} | -1.04239 | 0.08903 | 0.09183 | -11.4 | 0.000 |
| Constant | 2.29405 | 1.621 | 1.541 | 1.49 | 0.141 |
| Lam | 0.220701 | 0.2932 | 0.2742 | 0.805 | 0.424 |
| Lwcm | 0.430833 | 0.2706 | 0.2710 | 1.59 | 0.116 |
| Lavm | 0.798506 | 0.6423 | 0.8179 | 0.976 | 0.332 |
| LTbm | 0.631194 | 0.5266 | 0.4811 | 1.31 | 0.194 |
| Dindap | -0.896119 | 0.4568 | 0.4020 | -2.23 | 0.029 |
| DGl | -0.271300 | 0.4343 | 0.3819 | -0.710 | 0.480 |
| Dmanag | 1.04244 | 0.4722 | 0.3245 | 3.21 | 0.002 |
| Sha | -2.19093 | 1.178 | 1.393 | -1.57 | 0.120 |
| Cred | 0.153926 | 0.2419 | 0.1993 | 0.772 | 0.442 |
| Dcc | -0.950282 | 0.4608 | 0.4104 | -2.32 | 0.024 |
| Acc | -0.0518101 | 0.05028 | 0.04524 | -1.15 | 0.256 |
| FS | -0.0427543 | 0.1879 | 0.1793 | -0.238 | 0.812 |
| Age | -0.0274022 | 0.01857 | 0.01741 | -1.57 | 0.120 |
| Edu | -0.0112093 | 0.03649 | 0.03050 | -0.368 | 0.714 |

| | | | |
|---|---|---|---|
| log-likelihood | -59.5947674 | | |
| no. of observations | 109 | no. of parameters | 40 |
| AIC.T | 199.189535 | AIC | 1.82742692 |
| mean(Lym) | -0.674068 | var(Lym) | 1.10892 |
| \gamma: | 0.8036 | VAR(u)/VAR(total) | 0.5979 |
| Test of one-sided err | 39.975 | mixed Chi^2 !! | |

---- Sfa ----
The estimation sample is: 1 - 109
The dependent variable is: LYM

| | Coefficient | Std.Error | robust-SE | t-value | t-prob |
|---|---|---|---|---|---|
| Constant | 0.253072 | 0.2306 | 0.2814 | 0.899 | 0.372 |
| Lam | 0.181965 | 0.1180 | 0.1390 | 1.31 | 0.195 |
| Lwcm | 0.518298 | 0.08905 | 0.06848 | 7.57 | 0.000 |
| Lavm | 0.632744 | 0.1670 | 0.2167 | 2.92 | 0.005 |
| LTcm | 0.116541 | 0.1916 | 0.2334 | 0.499 | 0.619 |
| PIA | 0.0433085 | 0.9878 | 1.806 | 0.0240 | 0.981 |
| DL3 | 0.196063 | 0.2471 | 0.3118 | 0.629 | 0.532 |
| DL4 | 0.0325140 | 0.1847 | 0.2142 | 0.152 | 0.880 |
| DL5 | -0.0854283 | 0.1954 | 0.2227 | -0.384 | 0.702 |
| .5*Lam^2 | 0.0159455 | 0.09187 | 0.08910 | 0.179 | 0.858 |
| .5*Lwcm^2 | 0.0689777 | 0.05974 | 0.04648 | 1.48 | 0.142 |
| .5*Lavm^2 | 0.300964 | 0.1386 | 0.1146 | 2.63 | 0.011 |
| .5*LTcm^2 | -0.107567 | 0.1438 | 0.1224 | -0.879 | 0.382 |
| .5*PIA^2 | 0.634153 | 2.108 | 3.908 | 0.162 | 0.872 |
| Lam*Lwcm | 0.103386 | 0.05003 | 0.04945 | 2.09 | 0.040 |
| Lam*Lavm | -0.0887686 | 0.07134 | 0.07750 | -1.15 | 0.256 |
| Lam*LTcm | -0.0473873 | 0.1056 | 0.1226 | -0.387 | 0.700 |
| Lam*PIA | 0.328913 | 0.1913 | 0.1533 | 2.15 | 0.035 |
| Lwcm*Lavm | -0.0286932 | 0.08067 | 0.07835 | -0.366 | 0.715 |
| Lwcm*LTcm | 0.0462800 | 0.09537 | 0.08066 | 0.574 | 0.568 |
| Lwcm*PIA | 0.205122 | 0.1218 | 0.09423 | 2.18 | 0.033 |
| Lavm*LTcm | -0.0607920 | 0.1068 | 0.1121 | -0.542 | 0.589 |
| Lavm*PIA | -0.581816 | 0.2482 | 0.2049 | -2.84 | 0.006 |
| LTcm*PIA | 0.409117 | 0.3368 | 0.4600 | 0.889 | 0.377 |
| ln{\sigma_v} | -1.09885 | 0.09492 | 0.08602 | -12.8 | 0.000 |
| Constant | 1.57185 | 1.456 | 1.302 | 1.21 | 0.232 |
| Lam | 0.497918 | 0.3047 | 0.3552 | 1.40 | 0.165 |
| Lwcm | 0.278103 | 0.2489 | 0.2314 | 1.20 | 0.234 |
| Lavm | 0.379781 | 0.3789 | 0.4093 | 0.928 | 0.357 |
| LTcm | 0.707161 | 0.6023 | 0.7243 | 0.976 | 0.332 |
| Dindap | -0.994286 | 0.4462 | 0.3704 | -2.68 | 0.009 |
| Dmanag | 1.05445 | 0.4872 | 0.4081 | 2.58 | 0.012 |
| DGl | -0.189910 | 0.4244 | 0.4159 | -0.457 | 0.649 |
| Sha | -1.31341 | 0.7050 | 0.7116 | -1.85 | 0.069 |
| Cred | 0.142514 | 0.2283 | 0.1682 | 0.847 | 0.400 |
| Dcc | -0.681348 | 0.3922 | 0.3935 | -1.73 | 0.088 |
| Acc | -0.0297673 | 0.04865 | 0.04453 | -0.668 | 0.506 |
| FS | -0.0225023 | 0.1709 | 0.1568 | -0.143 | 0.886 |
| Age | -0.0246750 | 0.01720 | 0.01603 | -1.54 | 0.128 |
| Edu | 0.00699421 | 0.03241 | 0.02856 | 0.245 | 0.807 |

| | | | |
|---|---|---|---|
| log-likelihood | -58.1510545 | | |
| no. of observations | 109 | no. of parameters | 40 |
| AIC.T | 196.302109 | AIC | 1.80093678 |
| mean(Lym) | -0.674068 | var(Lym) | 1.10892 |
| \gamma: | 0.8173 | VAR(u)/VAR(total) | 0.6191 |
| Test of one-sided err | 40.358 | mixed Chi^2 !! | |

---- Sfa ----
The estimation sample is: 1 - 109
The dependent variable is: LYM

| | **Coefficient** | **Std.Error** | **robust-SE** | **t-value** | **t-prob** |
|---|---|---|---|---|---|
| Constant | 0.181442 | 0.2801 | 0.6612 | 0.274 | 0.785 |
| Lam | 0.0795313 | 0.1430 | 0.3258 | 0.244 | 0.808 |
| Lwcm | 0.544290 | 0.09676 | 0.07289 | 7.47 | 0.000 |
| Lavm | 0.748448 | 0.2113 | 0.5064 | 1.48 | 0.144 |
| LTdm | 0.216003 | 0.2610 | 0.5962 | 0.362 | 0.718 |
| PIA | -0.691414 | 1.374 | 4.552 | -0.152 | 0.880 |
| DL3 | 0.215529 | 0.2889 | 0.6095 | 0.354 | 0.725 |
| DL4 | 0.0617086 | 0.1872 | 0.2311 | 0.267 | 0.790 |
| DL5 | -0.0107570 | 0.1987 | 0.2023 | -0.0532 | 0.958 |
| .5*Lam^2 | -0.0141955 | 0.09066 | 0.09016 | -0.157 | 0.875 |
| .5*Lwcm^2 | 0.0791015 | 0.06377 | 0.04649 | 1.70 | 0.093 |
| .5*Lavm^2 | 0.267644 | 0.1476 | 0.2090 | 1.28 | 0.205 |
| .5*LTdm^2 | 0.0223866 | 0.1539 | 0.1748 | 0.128 | 0.898 |
| .5*PIA^2 | 2.15989 | 2.955 | 9.832 | 0.220 | 0.827 |
| Lam*Lwcm | 0.0720238 | 0.05376 | 0.05085 | 1.42 | 0.161 |
| Lam*Lavm | -0.0447727 | 0.07474 | 0.1236 | -0.362 | 0.718 |
| Lam*LTdm | -0.144087 | 0.1229 | 0.2426 | -0.594 | 0.554 |
| Lam*PIA | 0.316773 | 0.2021 | 0.2068 | 1.53 | 0.130 |
| Lwcm*Lavm | 0.0225228 | 0.08631 | 0.1064 | 0.212 | 0.833 |
| Lwcm*LTdm | 0.105502 | 0.1145 | 0.1095 | 0.964 | 0.338 |
| Lwcm*PIA | 0.152230 | 0.1405 | 0.1952 | 0.780 | 0.438 |
| Lavm*LTdm | -0.0272075 | 0.1039 | 0.1064 | -0.256 | 0.799 |
| Lavm*PIA | -0.520815 | 0.2816 | 0.4770 | -1.09 | 0.279 |
| LTdm*PIA | -0.0819648 | 0.4526 | 0.8780 | -0.0934 | 0.926 |
| ln{\sigma_v} | -1.06946 | 0.1366 | 0.3385 | -3.16 | 0.002 |
| Constant | 2.05048 | 1.651 | 2.741 | 0.748 | 0.457 |
| Lam | 0.313167 | 0.4422 | 1.282 | 0.244 | 0.808 |
| Lwcm | 0.375432 | 0.2734 | 0.5383 | 0.697 | 0.488 |
| Lavm | 0.553849 | 1.006 | 3.249 | 0.170 | 0.865 |
| LTdm | 0.637621 | 0.5673 | 0.9981 | 0.639 | 0.525 |
| Dindap | -0.861170 | 0.3976 | 0.3281 | -2.62 | 0.011 |
| Dmanag | 1.01900 | 0.4519 | 0.4535 | 2.25 | 0.028 |
| DGl | -0.328437 | 0.4300 | 0.6472 | -0.507 | 0.613 |
| Sha | -1.80339 | 1.542 | 4.693 | -0.384 | 0.702 |
| Cred | 0.206036 | 0.2575 | 0.4762 | 0.433 | 0.667 |
| Dcc | -0.919615 | 0.4697 | 0.8675 | -1.06 | 0.293 |
| Acc | -0.0439790 | 0.04995 | 0.08307 | -0.529 | 0.598 |
| FS | -0.0217856 | 0.1782 | 0.1719 | -0.127 | 0.900 |
| Age | -0.0254166 | 0.01749 | 0.02219 | -1.15 | 0.256 |
| Edu | -0.00646577 | 0.03836 | 0.07698 | -0.0840 | 0.933 |

| | | | |
|---|---|---|---|
| log-likelihood | -59.3236261 | | |
| no. of observations | 109 | no. of parameters | 40 |
| AIC.T | 198.647252 | AIC | 1.82245186 |
| mean(Lym) | -0.674068 | var(Lym) | 1.10892 |
| \gamma: | 0.8183 | VAR(u)/VAR(total) | 0.6207 |
| Test of one-sided err | 40.138 | mixed Chi^2 !! | |

---- Sfa ----
The estimation sample is: 1 - 109
The dependent variable is: LYM

| | Coefficient | Std.Error | robust-SE | t-value | t-prob |
|---|---|---|---|---|---|
| Constant | 0.165670 | 0.2505 | 0.3595 | 0.461 | 0.646 |
| Lam | 0.0719269 | 0.1156 | 0.1187 | 0.606 | 0.546 |
| Lwcm | 0.536266 | 0.09527 | 0.06915 | 7.75 | 0.000 |
| Lavm | 0.758754 | 0.1735 | 0.2118 | 3.58 | 0.001 |
| LTem | 0.118844 | 0.2167 | 0.3501 | 0.339 | 0.735 |
| PIA | -0.760788 | 0.9010 | 1.800 | -0.423 | 0.674 |
| DL3 | 0.173265 | 0.2388 | 0.2755 | 0.629 | 0.531 |
| DL4 | 0.0632261 | 0.1870 | 0.1958 | 0.323 | 0.748 |
| DL5 | -0.0284597 | 0.1998 | 0.1970 | -0.144 | 0.886 |
| .5*Lam^2 | -0.0172508 | 0.09391 | 0.1121 | -0.154 | 0.878 |
| .5*Lwcm^2 | 0.0807665 | 0.06406 | 0.04427 | 1.82 | 0.072 |
| .5*Lavm^2 | 0.289233 | 0.1431 | 0.1274 | 2.27 | 0.026 |
| .5*LTem^2 | -0.0103614 | 0.1232 | 0.1031 | -0.101 | 0.920 |
| .5*PIA^2 | 2.27360 | 2.073 | 4.334 | 0.525 | 0.602 |
| Lam*Lwcm | 0.0737326 | 0.05334 | 0.04813 | 1.53 | 0.130 |
| Lam*Lavm | -0.0395447 | 0.07030 | 0.07625 | -0.519 | 0.606 |
| Lam*LTem | -0.139154 | 0.1089 | 0.1120 | -1.24 | 0.218 |
| Lam*PIA | 0.293725 | 0.1960 | 0.1847 | 1.59 | 0.116 |
| Lwcm*Lavm | 0.0128943 | 0.08409 | 0.08020 | 0.161 | 0.873 |
| Lwcm*LTem | 0.0933245 | 0.1149 | 0.1256 | 0.743 | 0.460 |
| Lwcm*PIA | 0.164424 | 0.1354 | 0.1137 | 1.45 | 0.153 |
| Lavm*LTem | -0.0460519 | 0.1034 | 0.1373 | -0.335 | 0.738 |
| Lavm*PIA | -0.488554 | 0.2576 | 0.2806 | -1.74 | 0.086 |
| LTem*PIA | -0.0258541 | 0.4005 | 0.4467 | -0.0579 | 0.954 |
| ln{\sigma_v} | -1.05611 | 0.09615 | 0.09869 | -10.7 | 0.000 |
| Constant | 2.08446 | 1.507 | 1.416 | 1.47 | 0.146 |
| Lam | 0.245129 | 0.3143 | 0.4423 | 0.554 | 0.581 |
| Lwcm | 0.384304 | 0.2552 | 0.2920 | 1.32 | 0.192 |
| Lavm | 0.742407 | 0.7004 | 1.282 | 0.579 | 0.564 |
| LTem | 0.502629 | 0.5104 | 0.7346 | 0.684 | 0.496 |
| Dindap | -0.843231 | 0.4126 | 0.3741 | -2.25 | 0.027 |
| Dmanag | 1.00554 | 0.4463 | 0.3107 | 3.24 | 0.002 |
| DGl | -0.345213 | 0.4269 | 0.4156 | -0.831 | 0.409 |
| Sha | -2.02200 | 1.196 | 1.959 | -1.03 | 0.306 |
| Cred | 0.141220 | 0.2475 | 0.2564 | 0.551 | 0.584 |
| Dcc | -0.925699 | 0.4437 | 0.4266 | -2.17 | 0.033 |
| Acc | -0.0475213 | 0.05102 | 0.06182 | -0.769 | 0.445 |
| FS | -0.0269226 | 0.1725 | 0.1758 | -0.153 | 0.879 |
| Age | -0.0242552 | 0.01746 | 0.01726 | -1.40 | 0.165 |
| Edu | -0.00961762 | 0.03606 | 0.03839 | -0.251 | 0.803 |

| | | | |
|---|---|---|---|
| log-likelihood | -59.5430935 | | |
| no. of observations | 109 | no. of parameters | 40 |
| AIC.T | 199.086187 | AIC | 1.82647878 |
| mean(Lym) | -0.674068 | var(Lym) | 1.10892 |
| \gamma: | 0.8138 | VAR(u)/VAR(total) | 0.6137 |
| Test of one-sided err | 39.783 | mixed Chi^2 !! | |

# Appendix 4

# Tobit and Probit Estimations for Crop and Livestock production

### Specialized Crop Production

**Tobit by ML**

**Dependent variable: CRED**

| Variable | ML estimates | (t-value) | [p-value] |
|---|---|---|---|
| Cosntant | -2.4320993 | (-6.2874) | [0.00000] |
| Lam | -0.2348572 | (-1.0222) | [0.30670] |
| Lwcm | 1.3762211 | (7.6008) | [0.00000] |
| Ltam | 0.7045365 | (1.6128) | [0.10680] |
| Dindap | 1.4817654 | (4.0668) | [0.00005] |
| Dmanag | -0.2296147 | (-0.5677) | [0.57021] |
| Dex | 0.5347326 | (1.0460) | [0.29557] |
| Sha | 0.9753192 | (2.3662) | [0.01797] |
| Acc | 0.0634526 | (1.3616) | [0.17334] |
| FS | 0.1195951 | (1.8021) | [0.07153] |
| Age | 0.0048960 | (0.8421) | [0.39975] |
| Edu | -0.0946991 | (-3.2055) | [0.00135] |
| DL3 | -0.6555337 | (-1.6136) | [0.10661] |
| DL4 | 0.5714065 | (1.0219) | [0.30684] |
| DL5 | 0.7898910 | (1.0098) | [0.31259] |
| PIA | 0.1628450 | (0.4404) | [0.65962] |
| ***L(Y/A)*** | ***-0.4141337*** | ***(-6.8528)*** | ***[0.00000]*** |
| ***DOPR*** | ***-0.4724962*** | ***(-0.6250)*** | ***[0.53194]*** |
| ***OA*** | ***-0.0421629*** | ***(-1.1948)*** | ***[0.23217]*** |
| ***CS*** | ***-0.4322228*** | ***(-1.8575)*** | ***[0.06325]*** |
| ***DINDTYPE*** | ***1.3420407*** | ***(8.7535)*** | ***[0.00000]*** |

Standard error of u
s= 2.7703940 (14.5459) [0.00000]
(The p-values are two-sided and based on the normal approximation]
Log likelihood: -3.39852780538E+002
Pseudo R^2: 0.30365
Sample size (n): 342

### Specialized Livestock Production

**Tobit by ML**

**Dependent variable: CRED**

| Variable | ML estimates | (t-value) | [p-value] |
|---|---|---|---|
| Constant | -3.3803036 | (-6.2709) | [0.00000] |
| Lwcm | 0.2170877 | (1.9291) | [0.05372] |
| Lavm | -0.0224273 | (-0.1431) | [0.88620] |
| Dindap | 1.3312241 | (5.0032) | [0.00000] |
| Dmanag | -0.3095714 | (-1.3667) | [0.17173] |
| Dex | 0.6744983 | (2.5012) | [0.01238] |
| DGl | 0.2630178 | (1.2932) | [0.19593] |
| Sha | 0.5633039 | (1.8810) | [0.05998] |
| Acc | -0.1411088 | (-1.3234) | [0.18571] |
| FS | 0.1230888 | (2.5692) | [0.01019] |
| Age | 0.0138768 | (3.5569) | [0.00038] |
| Edu | 0.0461681 | (2.7489) | [0.00598] |
| PIA | -0.2978807 | (-0.8176) | [0.41358] |
| ***DL5*** | ***0.9935137*** | ***(4.0680)*** | ***[0.00005]*** |
| ***L(Y/A)*** | ***0.0444472*** | ***(0.9438)*** | ***[0.34526]*** |
| ***OA*** | ***-0.0204873*** | ***(-3.4322)*** | ***[0.00060]*** |
| ***DOPR*** | ***0.3956253*** | ***(1.4977)*** | ***[0.13421]*** |
| ***CS*** | ***0.0908891*** | ***(0.6517)*** | ***[0.51458]*** |
| ***DINDTYPE*** | ***-0.3909268*** | ***(-3.3641)*** | ***[0.00077]*** |

Standard error of u
s= 0.8597533 (6.9932) [0.00000]
[The p-values are two-sided and based on the normal approximation]

Log likelihood: -5.36580986965E+001
Pseudo R^2: 0.53402
Sample size (n): 109

Source: Own calculations using survey data

## Specialized Crop Production

**Probit by ML**

**Dependent variable: DCC**

| Variable | Coefficient | Std.Error | t-value | t-prob |
|---|---|---|---|---|
| Constant | -1.15471 | 0.9170 | -1.26 | 0.209 |
| Lam | -0.0574974 | 0.1448 | -0.397 | 0.692 |
| Lwcm | 0.0441906 | 0.1058 | 0.417 | 0.677 |
| Ltam | -0.135831 | 0.1749 | -0.777 | 0.438 |
| DL3 | -0.256866 | 0.2117 | -1.21 | 0.226 |
| DL4 | 0.152149 | 0.2901 | 0.524 | 0.600 |
| DL5 | 0.990816 | 0.3747 | 2.64 | 0.009 |
| PIA | 0.569962 | 0.2282 | 2.50 | 0.013 |
| Dindap | 0.0608032 | 0.2105 | 0.289 | 0.773 |
| Dmanag | 0.121299 | 0.1665 | 0.729 | 0.467 |
| Dex | 0.134947 | 0.2130 | 0.633 | 0.527 |
| Sha | 0.466679 | 0.2842 | 1.64 | 0.102 |
| Acc | 0.0143128 | 0.01883 | 0.760 | 0.448 |
| FS | 0.171865 | 0.05573 | 3.08 | 0.002 |
| Age | -0.0150042 | 0.005858 | -2.56 | 0.011 |
| Edu | 0.00950940 | 0.01262 | 0.753 | 0.452 |
| ***L(Y/A)*** | ***-0.000678420*** | ***0.1165*** | ***-0.00582*** | ***0.995*** |
| ***DOPR*** | ***-0.205668*** | ***0.3155*** | ***-0.652*** | ***0.515*** |
| ***OA*** | ***0.00908554*** | ***0.01510*** | ***0.602*** | ***0.548*** |
| ***CS*** | ***0.273985*** | ***0.1567*** | ***1.75*** | ***0.081*** |
| ***DINDTYPE*** | ***-0.0868651*** | ***0.1292*** | ***-0.672*** | ***0.502*** |

| | | | |
|---|---|---|---|
| log-likelihood | -207.817143 | no. of states | 2 |
| no. of observations | 342 | no. of parameters | 21 |
| zeroline log-lik | -237.0563 | Test: Chi^2( 21) | 58.478 [0.0000]** |
| AIC | 457.634287 | AIC/n | 1.33811195 |
| mean(Dcc) | 0.418129 | var(Dcc) | 0.243297 |

Newton estimation (eps1=0.0001; eps2=0.005): Strong convergence

Table of actual and predicted

| | State 0 | State 1 | Sum actual |
|---|---|---|---|
| State 0 | ***152*** | 47 | 199 |
| State 1 | 82 | ***61*** | 143 |
| Sum pred | 234 | 108 | **342** |

Source: Own calculations using survey data

## Specialized Livestock Production

**Probit by ML**

**Dependent variable: Dcc**

| Variable | Coefficient | Std.Error | t-value | t-prob |
|---|---|---|---|---|
| Constant | -2.24879 | 1.605 | -1.40 | 0.165 |
| Lwcm | -0.0318992 | 0.1428 | -0.223 | 0.824 |
| Lavm | 0.138256 | 0.2552 | 0.542 | 0.589 |
| Dindap | -0.117545 | 0.3976 | -0.296 | 0.768 |
| Dmanag | 0.685728 | 0.3922 | 1.75 | 0.084 |
| Dex | 0.110535 | 0.3800 | 0.291 | 0.772 |
| DGl | 0.117456 | 0.3165 | 0.371 | 0.711 |
| Sha | -1.53805 | 0.6271 | -2.45 | 0.016 |
| Acc | -0.0762911 | 0.06027 | -1.27 | 0.209 |
| FS | 0.168032 | 0.09482 | 1.77 | 0.080 |
| Age | -0.0132458 | 0.01200 | -1.10 | 0.273 |
| Edu | 0.00220146 | 0.03226 | 0.0682 | 0.946 |
| PIA | 0.474885 | 0.7764 | 0.612 | 0.542 |
| ***DL3*** | ***2.69161*** | ***1.162*** | ***2.32*** | ***0.023*** |
| ***DL4*** | ***0.989696*** | ***0.8335*** | ***1.19*** | ***0.238*** |
| ***DL5*** | ***1.54486*** | ***0.9817*** | ***1.57*** | ***0.119*** |
| ***L(Y/A)*** | ***0.353485*** | ***0.1662*** | ***2.13*** | ***0.036*** |
| ***OA*** | ***-0.00449562*** | ***0.009173*** | ***-0.490*** | ***0.625*** |
| ***DOPR*** | ***0.374124*** | ***0.3911*** | ***0.957*** | ***0.341*** |
| ***CS*** | ***-0.0902395*** | ***0.3155*** | ***-0.286*** | ***0.776*** |
| ***DINDTYPE*** | ***-0.0629468*** | ***0.1450*** | ***-0.434*** | ***0.665*** |

| | | | |
|---|---|---|---|
| log-likelihood | -57.448817 | no. of states | 2 |
| no. of observations | 109 | no. of parameters | 21 |
| zeroline log-lik | -75.55304 | Test: Chi^2( 21) | 36.208 [0.0207]* |
| AIC | 156.897634 | AIC/n | 1.43942783 |
| mean(Dcc) | 0.431193 | var(Dcc) | 0.245266 |

Newton estimation (eps1=0.0001; eps2=0.005): Strong convergence

Table of actual and predicted

| | State 0 | State 1 | Sum actual |
|---|---|---|---|
| State 0 | ***45*** | 17 | 62 |
| State 1 | 17 | ***30*** | 47 |
| Sum pred | 62 | 47 | **109.** |

Source: Own calculations using survey data

# Appendix 5

## Probit estimation for non-specialized production

**(Dependent variable: DOFF)**

Maximum likelihood estimation results

| Variable | Par. | ML estimate | t-value | [p-value] |
|---|---|---|---|---|
| x(1)=Lam | b(1) | 0.1040753 | 0.67 | [0.50449] |
| x(2)=Lwcm | b(2) | 0.1374928 | 0.96 | [0.33677] |
| x(3)=Ltam | b(3) | -0.8952037 | -2.96 | [0.00312] |
| x(4)=Lavm | b(4) | -0.0237879 | -0.13 | [0.89743] |
| x(5)=DcropLam | b(5) | -0.2219505 | -1.00 | [0.31630] |
| x(6)=DcropLwcm | b(6) | 0.1205135 | 0.59 | [0.55392] |
| x(7)=DcropLtam | b(7) | 0.3130862 | 0.83 | [0.40822] |
| x(8)=DcropLavm | b(8) | -0.0683471 | -0.30 | [0.76080] |
| x(9)=DLiveLam | b(9) | -0.1373538 | -0.62 | [0.53523] |
| x(10)=DLiveLwcm | b(10) | 0.0462048 | 0.22 | [0.82288] |
| x(11)=DLiveLtam | b(11) | 0.4374640 | 1.07 | [0.28250] |
| x(12)=DLiveLavm | b(12) | 0.1059610 | 0.33 | [0.73800] |
| x(13)=PIALwcm | b(13) | 0.2089072 | 1.07 | [0.28343] |
| x(14)=PIALavm | b(14) | -0.2409866 | -1.05 | [0.29221] |
| x(15)=PIA | b(15) | -0.1367433 | -0.43 | [0.66453] |
| x(16)=DLive | b(16) | 0.5764867 | 1.68 | [0.09365] |
| x(17)=Dcrop | b(17) | 0.4376492 | 1.27 | [0.20577] |
| x(18)=DL4 | b(18) | -0.0538636 | -0.19 | [0.85257] |
| x(19)=DL5 | b(19) | -0.3437629 | -1.06 | [0.28912] |
| x(20)=Dindap | b(20) | -0.0235668 | -0.13 | [0.90015] |
| x(21)=Dmanag | b(21) | 0.3219485 | 1.84 | [0.06523] |
| x(22)=Dex | b(22) | -0.2990100 | -1.57 | [0.11697] |
| x(23)=FS | b(23) | 0.3579334 | 3.45 | [0.00057] |
| x(24)=MFS | b(24) | 0.7421199 | 1.98 | [0.04720] |
| x(25)=Acc | b(25) | 0.0196519 | 0.80 | [0.42621] |
| x(26)=Age | b(26) | -0.0112269 | -1.66 | [0.09670] |
| x(27)=Edu | b(27) | 0.0207339 | 1.10 | [0.26934] |
| x(28)=OA | b(28) | 0.0010863 | 0.28 | [0.77589] |
| x(29)=Dopr | b(29) | -0.0634970 | -0.37 | [0.70875] |
| x(30)=Index | b(30) | -1.7770431 | -1.87 | [0.06213] |
| x(31)=CS | b(31) | -0.0513986 | -0.32 | [0.74519] |
| x(32)=Dindtype | b(32) | 0.1523505 | 1.59 | [0.11197] |
| x(33)=L(Y/FS) | b(33) | -0.2538393 | -2.05 | [0.04056] |
| x(34)=OTHERINCPC | b(34) | -0.0000009 | -1.88 | [0.06048] |
| x(35)=TST | b(35) | -0.0090211 | -1.03 | [0.30531] |
| x(36)=Inc2000 | b(36) | -0.2101933 | -2.45 | [0.01412] |
| x(37)=Depchild | b(37) | -1.6628906 | -2.41 | [0.01616] |
| x(38)=Depoldp | b(38) | -0.2429634 | -2.04 | [0.04105] |
| x(39)=Dsex | b(39) | -0.2630530 | -1.31 | [0.18949] |
| x(40)=1 | b(40) | 4.6374799 | 2.40 | [0.01655] |

[The two-sided p-values are based on the normal approximation]

Log likelihood: -2.15733722113E+002
Sample size (n): 384

Source: Own calculations using survey data

## Tobit estimation for non-specialized production
### (Dependent variable: CRED)

Maximum likelihood estimation results

| Variable | | ML estimates | (t-value) | [p-value] |
|---|---|---|---|---|
| x(1)=Lam | b(1)= | -0.0390510 | (-0.4854) | [0.62736] |
| x(2)=Lwcm | b(2)= | 0.2797735 | (3.7843) | [0.00015] |
| x(3)=Ltam | b(3)= | 0.1674326 | (1.0159) | [0.30969] |
| x(4)=Lavm | b(4)= | -0.0459215 | (-0.5419) | [0.58787] |
| x(5)=DcropLam | b(5)= | 0.0699217 | (0.5247) | [0.59978] |
| x(6)=DcropLwcm | b(6)= | 0.2769906 | (2.0785) | [0.03766] |
| x(7)=DcropLtam | b(7)= | -0.2667724 | (-1.2052) | [0.22811] |
| x(8)=DcropLavm | b(8)= | 0.0582914 | (0.5345) | [0.59297] |
| x(9)=DLiveLam | b(9)= | -0.0325901 | (-0.2390) | [0.81110] |
| x(10)=DLiveLwcm | b(10)= | -0.1767928 | (-1.3606) | [0.17364] |
| x(11)=DLivetam | b(11)= | 0.4678051 | (1.3348) | [0.18193] |
| x(12)=DLiveLavm | b(12)= | 0.3886763 | (1.6711) | [0.09470] |
| x(13)=PIALwcm | b(13)= | 0.2529985 | (1.6697) | [0.09498] |
| x(14)=PIALavm | b(14)= | 0.2063726 | (1.5120) | [0.13053] |
| x(15)=PIA | b(15)= | -0.1318350 | (-0.6901) | [0.49012] |
| x(16)=DLive | b(16)= | -0.5452184 | (-3.2407) | [0.00119] |
| x(17)=Dcrop | b(17)= | 0.1393014 | (0.9760) | [0.32905] |
| x(18)=DL4 | b(18)= | -0.2328961 | (-1.6199) | [0.10524] |
| x(19)=DL5 | b(19)= | -0.0165448 | (-0.1286) | [0.89771] |
| x(20)=Dindap | b(20)= | 0.5656471 | (4.4770) | [0.00001] |
| x(21)=Dmanag | b(21)= | 0.2040235 | (1.6861) | [0.09177] |
| x(22)=Dex | b(22)= | 0.0491213 | (0.3592) | [0.71944] |
| x(23)=Sha | b(23)= | -0.0505281 | (-0.3545) | [0.72296] |
| x(24)=FS | b(24)= | -0.0271305 | (-1.1464) | [0.25164] |
| x(25)=H/FS | b(25)= | -0.1089516 | (-0.6619) | [0.50802] |
| x(26)=Acc | b(26)= | 0.0054045 | (0.2492) | [0.80320] |
| x(27)=Age | b(27)= | 0.0039645 | (2.1378) | [0.03253] |
| x(28)=Edu | b(28)= | -0.0036087 | (-0.3838) | [0.70113] |
| x(29)=OA | b(29)= | 0.0026857 | (1.1220) | [0.26187] |
| x(30)=Dopr | b(30)= | 0.2547919 | (1.9411) | [0.05225] |
| x(31)=Index | b(31)= | 1.1504488 | (6.6115) | [0.00000] |
| x(32)=CS | b(32)= | 0.0666243 | (0.9219) | [0.35660] |
| x(33)=Dindtype | b(33)= | -0.3398950 | (-8.1118) | [0.00000] |
| x(34)=L(Y/FS) | b(34)= | 0.1244944 | (11.1134) | [0.00000] |
| x(35)=Otherincpc | b(35)= | -0.0000006 | (-1.5970) | [0.11027] |
| x(36)=TST | b(36)= | 0.1544944 | (0.7323) | [0.46398] |
| x(37)=Inc2000 | b(37)= | 0.0984934 | (3.4755) | [0.00051] |
| x(38)=Depchild | b(38)= | 0.4715487 | (1.4475) | [0.14775] |
| x(39)=Depoldp | b(39)= | -0.0497497 | (-0.7218) | [0.47044] |
| x(40)=Dsex | b(40)= | 0.0296027 | (0.2867) | [0.77435] |
| x(41)=1 | b(41)= | -2.6697242 | (-13.3506) | [0.00000] |
| Standard error of u | s= | 0.9213411 | (16.8943) | [0.00000] |

| | |
|---|---|
| Log likelihood: | -2.72313452521E+002 |
| Pseudo R^2: | 0.44482 |
| Sample size (n): | 384 |
| Information criteria: | |
| Akaike: | 1.637049 |
| Hannan-Quinn: | 1.808440 |
| Schwarz: | 2.069151 |

Source: Own calculations using survey data

# Appendix 6
## Testing hypothesis of liquidity by Heckman's estimation procedure

| Variables | CROP | | | | LIVESTOCK | | | | MIX | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Constrained | | Unconstrained | | Constrained | | Unconstrained | | Constrained | | Unconstrained | |
| | Coeff. | t-ratio | Coeff. | t-ratio | Coeff. | t-ratio | Coeff. | t-ratio | Coeff. | t-ratio | Coeff. | t-ratio |
| CONSTANT | 2.5370 | 7.43 | 2.5412 | 9.80 | -0.15297 | -0.33 | -0.42639 | -1.02 | 1.00936 | 2.02 | 1.42419 | 2.31 |
| LA | 0.5946 | 10.62 | 0.6437 | 11.72 | 0.20210 | 2.41 | 0.11223 | 1.28 | 0.00229 | 0.02 | -0.01748 | -0.16 |
| LT | 0.2683 | 2.23 | 0.0057 | 0.04 | 0.06680 | 0.60 | -0.00002 | 0.00 | 0.00511 | 0.04 | 0.00202 | 0.01 |
| LAV | -0.0181 | -0.77 | -0.0487 | -2.00 | 0.79183 | 7.52 | 0.75492 | 7.50 | 0.64270 | 5.18 | 0.52810 | 4.14 |
| PIA | 0.1043 | 1.00 | 0.1779 | 1.96 | -0.06863 | -0.51 | 0.17547 | 1.14 | -0.16905 | -1.21 | 0.18274 | 1.08 |
| DL3 | 0.1126 | 1.48 | -0.0883 | -1.12 | -0.20587 | -0.88 | 0.07137 | 0.25 | 0.22859 | 0.86 | 0.32715 | 0.95 |
| DL4 | -0.2995 | -3.25 | -0.4081 | -4.12 | 0.07413 | 0.48 | 0.16559 | 1.12 | -0.13002 | -0.57 | 0.16216 | 0.62 |
| DL5 | -0.3035 | -2.21 | -0.4243 | -3.00 | -0.11703 | -0.62 | 0.20013 | 1.14 | -0.29610 | -1.27 | 0.03092 | 0.12 |
| EDU | 0.0065 | 1.26 | 0.0047 | 1.01 | 0.00794 | 0.91 | 0.00261 | 0.40 | 0.00907 | 1.61 | 0.00328 | 0.57 |
| AGE | -0.0002 | -0.09 | -0.0003 | -0.14 | 0.00575 | 1.93 | 0.00308 | 1.03 | 0.00125 | 0.42 | -0.00479 | -1.65 |
| **CRED** | ***0.0001*** | ***3.55*** | ***0.0001*** | ***4.53*** | ***-0.00001*** | ***-0.12*** | ***0.00005*** | ***0.51*** | ***0.00021*** | ***2.63*** | ***0.00010*** | ***1.08*** |
| **NDEPEND** | ***-0.0394*** | ***-1.74*** | ***0.0116*** | ***0.46*** | ***-0.04508*** | ***-1.60*** | ***0.00520*** | ***0.18*** | ***0.05294*** | ***1.82*** | ***0.02023*** | ***0.68*** |
| LAMBDA | -0.2894 | -2.00 | -0.3796 | -2.37 | -0.23829 | -1.50 | -0.28869 | -1.78 | -0.24010 | -1.72 | 0.25320 | 1.68 |
| ***Observations*** | 209 | | 248 | | 97 | | 116 | | 74 | | 91 | |
| ***R-squared*** | 0.66 | | 0.62 | | 0.63 | | 0.63 | | 0.68 | | 0.43 | |
| ***F test*** | 32.93 | | 31.83 | | 12.14 | | 14.38 | | 11.16 | | 8.45 | |

Source: Own calculations using survey data

# Appendix 7
# Switching regression model estimations by Heckman's procedure

**CROP PRODUCTION**

| VARIABLES | CREDIT CONSTRAINT | | | | CREDIT | | | |
|---|---|---|---|---|---|---|---|---|
| | Constrained | | Unconstrained | | With access | | Whithout access | |
| | Coeff. | t-ratio | Coeff. | t-ratio | Coeff. | t-ratio | Coeff. | t-ratio |
| CONSTANT | 0.977 | 3.15 | 0.959 | 4.50 | 0.45409 | 1.59 | 1.0978 | 5.74 |
| LA | 0.320 | 5.67 | 0.249 | 5.09 | 0.24123 | 4.06 | 0.2504 | 5.64 |
| LT | 0.241 | 2.38 | 0.038 | 0.41 | 0.37566 | 3.81 | 0.1426 | 1.93 |
| LWC | 0.528 | 9.73 | 0.631 | 14.08 | 0.60461 | 10.31 | 0.5356 | 12.86 |
| LAV | -0.002 | -0.10 | -0.035 | -1.98 | -0.02297 | -1.23 | 0.0071 | 0.49 |
| PIA | 0.069 | 0.84 | -0.033 | -0.48 | 0.08114 | 1.02 | 0.0909 | 1.90 |
| DL3 | 0.073 | 1.17 | -0.117 | -2.05 | 0.02265 | 0.32 | -0.0687 | -1.46 |
| DL4 | -0.120 | -1.56 | -0.312 | -4.21 | -0.00680 | -0.08 | -0.2759 | -4.71 |
| DL5 | -0.152 | -1.39 | -0.474 | -4.47 | -0.05093 | -0.46 | -0.3079 | -4.06 |
| EDU | 0.005 | 1.20 | 0.000 | 0.05 | 0.01089 | 2.23 | 0.0025 | 0.86 |
| AGE | 0.001 | 0.41 | 0.002 | 1.06 | 0.00082 | 0.47 | -0.0003 | -0.27 |
| DEX | -0.017 | -0.34 | -0.011 | -0.23 | -0.01333 | -0.30 | 0.0020 | 0.04 |
| DCRED | -0.028 | -0.57 | 0.053 | 1.15 | | | | |
| CRED | | | | | 0.00002 | 1.75 | | |
| LAMBDA | -0.174 | -1.54 | -0.296 | -2.59 | -0.20455 | -3.01 | -0.1559 | -2.98 |
| **Observations** | 209 | | 248 | | 171 | | 286 | |
| **R-squared** | 0.76 | | 0.80 | | 0.82 | | 0.74 | |
| **F-test** | 47.32 | | 75.51 | | 56.27 | | 64.91 | |

**LIVESTOCK PRODUCTION**

| VARIABLES | CREDIT CONSTRAINT | | | | CREDIT | | | |
|---|---|---|---|---|---|---|---|---|
| | Constrained | | Unconstrained | | With access | | Whithout access | |
| | Coeff. | t-ratio | Coeff. | t-ratio | Coeff. | t-ratio | Coeff. | t-ratio |
| CONSTANT | -0.512 | -1.26 | -0.476 | -1.39 | -0.69672 | -1.32 | -0.2940 | -1.04 |
| LA | 0.179 | 2.41 | 0.011 | 0.15 | -0.04073 | -0.54 | 0.0825 | 1.46 |
| LT | 0.158 | 1.49 | 0.153 | 1.41 | 0.16275 | 0.97 | 0.1353 | 1.54 |
| LWC | 0.254 | 4.46 | 0.377 | 5.95 | 0.18711 | 2.07 | 0.3454 | 7.13 |
| LAV | 0.618 | 6.36 | 0.517 | 5.65 | 0.80424 | 6.69 | 0.4906 | 6.17 |
| PIA | -0.072 | -0.60 | 0.057 | 0.46 | -0.08635 | -0.65 | 0.1437 | 1.56 |
| DL3 | -0.050 | -0.23 | 0.012 | 0.05 | 0.13035 | 0.47 | 0.1021 | 0.75 |
| DL4 | 0.151 | 1.09 | 0.068 | 0.57 | -0.02893 | -0.18 | 0.1990 | 2.16 |
| DL5 | -0.036 | -0.21 | 0.086 | 0.62 | 0.02691 | 0.16 | 0.1797 | 1.70 |
| EDU | 0.006 | 0.78 | -0.001 | -0.24 | 0.00194 | 0.34 | -0.0037 | -0.70 |
| AGE | 0.003 | 1.29 | 0.001 | 0.61 | -0.00016 | -0.07 | 0.0002 | 0.13 |
| DEX | -0.028 | -0.45 | -0.136 | -2.09 | 0.00779 | 0.15 | -0.1147 | -1.79 |
| DCRED | -0.023 | -0.38 | -0.056 | -0.82 | | | | |
| CRED | | | | | -0.00002 | -0.41 | | |
| LAMBDA | -0.146 | -0.94 | -0.113 | -0.79 | 0.05551 | 0.93 | 0.0111 | 0.14 |
| **Observations** | 97 | | 116 | | 64 | | 149 | |
| **R-squared** | 0.69 | | 0.71 | | 0.75 | | 0.67 | |
| **F-test** | 1.13 | | 19.91 | | 11.59 | | 22.37 | |

**MIX PRODUCTION**

| VARIABLES | CREDIT CONSTRAINT | | | | CREDIT | | | |
|---|---|---|---|---|---|---|---|---|
| | Constrained | | Unconstrained | | With access | | Whithout access | |
| | Coeff. | t-ratio | Coeff. | t-ratio | Coeff. | t-ratio | Coeff. | t-ratio |
| CONSTANT | 0.102 | 0.25 | 0.893 | 1.49 | 1.43378 | 2.21 | 0.3457 | 0.82 |
| LA | -0.067 | -0.88 | -0.065 | -0.62 | -0.09470 | -1.09 | -0.0581 | -0.69 |
| LT | 0.202 | 1.69 | 0.137 | 0.71 | 0.16009 | 1.01 | 0.1287 | 0.99 |
| LWC | 0.382 | 5.65 | 0.404 | 4.82 | 0.40907 | 4.43 | 0.3770 | 5.64 |
| LAV | 0.432 | 3.93 | 0.334 | 2.66 | 0.20980 | 1.64 | 0.3496 | 3.57 |
| PIA | -0.072 | -0.56 | 0.149 | 0.89 | -0.01481 | -0.12 | -0.0290 | -0.32 |
| DL3 | 0.325 | 1.62 | 0.010 | 0.03 | 0.16932 | 0.44 | 0.2391 | 1.21 |
| DL4 | -0.050 | -0.28 | -0.055 | -0.23 | -0.21651 | -0.75 | -0.0964 | -0.57 |
| DL5 | -0.140 | -0.77 | -0.162 | -0.66 | -0.32771 | -1.13 | -0.1514 | -0.88 |
| EDU | 0.006 | 1.27 | 0.000 | -0.06 | -0.00041 | -0.08 | -0.0001 | -0.02 |
| AGE | 0.001 | 0.50 | -0.003 | -1.01 | -0.00315 | -1.31 | 0.0032 | 1.68 |
| DEX | 0.018 | 0.27 | 0.015 | 0.20 | -0.01366 | -0.20 | -0.0776 | -1.14 |
| DCRED | 0.052 | 0.73 | 0.079 | 0.78 | | | | |
| CRED | | | | | 0.00004 | 0.54 | | |
| LAMBDA | -0.043 | -0.31 | 0.329 | 1.80 | -0.23351 | -2.75 | -0.2284 | -3.30 |
| **Observations** | 74 | | 91 | | 66 | | 99 | |
| **R-squared** | 0.76 | | 0.55 | | 0.71 | | 0.62 | |
| **F-test** | 14.95 | | 7.85 | | 9.57 | | 11.66 | |

Source: Own calculations using survey data

# Appendix 8
# Credit effects on sectorial production value using a Tobit specification

## Appendix 8.1
## Tobit estimations of the variable CRED (Carter and Sial, 1996)

| TOBIT MODELS | | | | | | |
|---|---|---|---|---|---|---|
| | CROP | | LIVESTOCK | | MIX | |
| VARIABLES | Coeff. | t-ratio | Coeff. | t-ratio | Coeff. | t-ratio |
| CONSTANT | -2.92274 | -3.75 | -3.89996 | -2.39 | -4.92619 | -2.63 |
| LA | 0.37830 | 2.54 | -0.03683 | -0.16 | 0.00203 | 0.01 |
| LAV | 0.05793 | 1.30 | 0.46670 | 1.24 | -0.00312 | -0.01 |
| PIA | 0.03691 | 0.23 | -0.37216 | -0.86 | -0.25886 | -0.88 |
| DL3 | -0.15649 | -1.03 | -0.21577 | -0.27 | -0.70500 | -0.79 |
| DL4 | -0.00085 | 0.00 | 0.14188 | 0.28 | 0.29757 | 0.45 |
| DL5 | 0.29279 | 1.26 | 0.80609 | 1.52 | 0.43855 | 0.65 |
| SHA | 0.31389 | 1.61 | -0.00296 | -0.01 | 0.73146 | 2.37 |
| ACC | -0.00262 | -0.20 | -0.05550 | -1.38 | -0.00445 | -0.15 |
| AGE | -0.00310 | -0.76 | 0.01553 | 1.83 | -0.00495 | -0.71 |
| EDU | -0.01553 | -1.35 | 0.04743 | 1.92 | -0.00382 | -0.21 |
| FS | 0.00645 | 0.16 | 0.14882 | 1.98 | -0.01514 | -0.25 |
| DOPR | -0.04632 | -0.28 | 0.34621 | 1.77 | 0.39503 | 2.24 |
| CS | -0.11053 | -0.97 | 0.17546 | 0.94 | -0.11142 | -0.59 |
| INDEX | 1.73520 | 2.84 | 0.30894 | 0.52 | 1.60657 | 0.66 |
| LTI | 0.16589 | 1.15 | -0.30352 | -0.89 | 0.82142 | 2.85 |
| DEPEND | -0.32858 | -1.51 | -0.37696 | -0.97 | 0.14700 | 0.44 |
| ESTUDIO | -0.00415 | -0.86 | -0.00597 | -0.64 | 0.00974 | 1.15 |
| DSEX | -0.05842 | -0.38 | -0.09519 | -0.41 | -0.16901 | -0.91 |
| DINDAP | 1.15258 | 7.53 | 1.51777 | 5.76 | 1.39375 | 5.42 |
| DINDTIPO | 0.02907 | 0.53 | -0.32598 | -3.29 | -0.10649 | -1.32 |
| Sigma | 0.86199 | 15.88 | 0.92856 | 9.59 | 0.78546 | 9.97 |
| **LLF** | **-350.5** | | **-142.8** | | **-123.6** | |

Source: Own calculations using survey data

## Appendix 8.2
## OLS estimations of the production value function (LY) by sector corrected for heteroscedasticity using a Tobit specification
### OLS ESTIMATIONS CORREGITED BY HETEROSCEDASTICITY

| | CROP | | LIVESTOCK | | MIX | |
|---|---|---|---|---|---|---|
| VARIABLES | Coeff. | t-ratio | Coeff. | t-ratio | Coeff. | t-ratio |
| CONSTANT | 1.07572 | 5.61 | -0.35320 | -1.49 | 0.47762 | 1.53 |
| LA | 0.24453 | 3.75 | 0.15682 | 2.02 | -0.07984 | -0.80 |
| LWC | 0.52663 | 8.07 | 0.28971 | 5.01 | 0.36402 | 4.26 |
| LT | 0.22536 | 2.20 | 0.13992 | 1.38 | 0.07495 | 0.52 |
| LAV | 0.01434 | 0.66 | 0.52009 | 5.79 | 0.34134 | 3.38 |
| PIA | 0.12192 | 1.72 | 0.17499 | 1.31 | 0.09557 | 0.93 |
| DL3 | -0.09290 | -1.36 | 0.13571 | 0.69 | 0.24247 | 1.44 |
| DL4 | -0.22056 | -2.49 | 0.22849 | 1.92 | 0.00787 | 0.05 |
| DL5 | -0.24227 | -2.16 | 0.15378 | 1.16 | -0.03118 | -0.18 |
| EDU | 0.00295 | 0.56 | -0.00075 | -0.11 | -0.00335 | -0.70 |
| AGE | -0.00152 | -0.86 | 0.00074 | 0.34 | 0.00313 | 1.28 |
| DEX | -0.12184 | -1.09 | -0.02497 | -0.28 | -0.31754 | -2.42 |
| **CREDΦ** | **0.00001** | **1.99** | **-0.00007** | **-1.16** | **-0.00009** | **-1.23** |
| LAΦ | 0.01909 | 0.14 | -0.31972 | -1.85 | -0.00921 | -0.05 |
| LWCΦ | 0.06545 | 0.54 | 0.08576 | 0.57 | 0.05676 | 0.31 |
| LTΦ | -0.06627 | -0.36 | -0.05138 | -0.18 | 0.21849 | 0.76 |
| LAVΦ | -0.04589 | -1.14 | 0.15484 | 0.59 | 0.05993 | 0.27 |
| PIAΦ | -0.10051 | -0.70 | -0.39005 | -1.08 | -0.34968 | -1.71 |
| DL3Φ | 0.14471 | 0.96 | 0.04756 | 0.07 | 0.15158 | 0.43 |
| DL4Φ | 0.06460 | 0.36 | -0.22911 | -0.48 | -0.22353 | -0.64 |
| DL5Φ | -0.00170 | -0.01 | -0.03536 | -0.07 | -0.34209 | -1.01 |
| EDUΦ | 0.00561 | 0.44 | -0.00049 | -0.03 | 0.00698 | 0.72 |
| AGEΦ | 0.00486 | 1.26 | -0.00127 | -0.23 | -0.00498 | -1.10 |
| DEXΦ | 0.20031 | 1.12 | -0.08901 | -0.51 | 0.50036 | 2.42 |
| ***ϕ*** | **-0.49611** | **-1.49** | **-0.21572** | **-0.90** | **-0.12296** | **-0.44** |
| **R-squared** | **0.78** | | **0.71** | | **0.69** | |
| **F-test** | **66.25** | | **17.62** | | **12.48** | |
| **Observations** | **457** | | **213** | | **165** | |

Source: Own calculations using survey data

## Appendix 8.3
## Impact on the average production value of access to credit using a Tobit specification for variable CRED

| EFFECTS | CROP | LIVESTOCK | MIX |
|---|---|---|---|
| **Direct effect of credit** | ***0.02*** | ***0.00*** | *0.00* |
| **Indirect effect** | | | |
| **Observed factors** | *0.00* | *0.00* | *0.16* |
| **Unobserved factors** | *0.00* | *0.00* | *0.00* |
| **Total Effect* = $E(y_{1i} \mid D=1) - E(y_{2i} \mid D=1)$** | ***0.02*** | ***0.00*** | ***0.16*** |

* Total effect is the change of logarithm of production value, which is equivalent to its percentual change
Source: Own calculations using survey data

# Appendix 9
# Credit effects on sectorial production value using a Probit specification and omitting the variable working capital

## Appendix 9.1
## OLS estimations of the production value function (LY) by sector corrected for heteroscedasticity without the variable working capital

| VARIABLES | CROP | | LIVESTOCK | | MIX | |
|---|---|---|---|---|---|---|
| | Coeff. | t-ratio | Coeff. | t-ratio | Coeff. | t-ratio |
| ONE | 2.5205 | 14.138 | -0.210 | -0.808 | 1.516 | 4.617 |
| LA | 0.5633 | 7.481 | 0.198 | 2.469 | 0.021 | 0.199 |
| LT | 0.2114 | 2.375 | 0.021 | 0.204 | -0.141 | -1.090 |
| LAV | 0.0133 | 0.535 | 0.722 | 8.233 | 0.396 | 3.555 |
| PIA | 0.2385 | 3.365 | 0.269 | 1.787 | 0.132 | 1.227 |
| DL3 | -0.1396 | -1.874 | 0.208 | 0.966 | 0.322 | 2.104 |
| DL4 | -0.4166 | -4.715 | 0.287 | 2.074 | 0.041 | 0.254 |
| DL5 | -0.3075 | -2.361 | 0.204 | 1.295 | -0.004 | -0.026 |
| EDU | 0.0049 | 0.935 | 0.006 | 0.926 | 0.006 | 1.361 |
| AGE | -0.0045 | -2.437 | 0.001 | 0.488 | 0.002 | 0.976 |
| DEX | 0.0596 | 0.531 | 0.009 | 0.108 | -0.179 | -1.591 |
| **CREDϕ** | **0.0001** | **3.670** | **0.00001** | **0.109** | **0.00003** | **0.474** |
| LAϕ | -0.0417 | -0.247 | -0.397 | -1.996 | -0.159 | -0.748 |
| LTϕ | 0.0687 | 0.441 | -0.029 | -0.094 | 0.508 | 1.987 |
| LAVϕ | -0.0867 | -1.769 | 0.242 | 0.913 | 0.220 | 1.196 |
| PIAϕ | -0.0510 | -0.306 | -0.521 | -1.106 | -0.354 | -1.690 |
| DL3ϕ | 0.2516 | 1.463 | -0.219 | -0.291 | -0.202 | -0.649 |
| DL4ϕ | 0.1531 | 0.747 | -0.314 | -0.566 | -0.588 | -1.811 |
| DL5ϕ | -0.0148 | -0.054 | 0.022 | 0.038 | -0.791 | -2.546 |
| EDUϕ | 0.0200 | 1.476 | -0.013 | -0.843 | -0.009 | -0.902 |
| AGEϕ | 0.0103 | 2.391 | 0.000 | -0.018 | -0.004 | -0.932 |
| DEXϕ | -0.0325 | -0.170 | -0.015 | -0.079 | 0.332 | 1.762 |
| ***ϕ*** | **-0.7569** | **-2.269** | **-0.024** | **-0.085** | **-0.325** | **-1.411** |
| **R-squared** | 0.66 | | 0.61 | | 0.58 | |
| **F-test** | 39.3 | | 13.58 | | 9.13 | |
| **Observations** | 457 | | 213 | | 165 | |

Source: Own calculations using survey data

## Appendix 9.2
## Impact on the average production value of access to credit without the variable working capital

| EFFECTS | CROP | LIVESTOCK | MIX |
|---|---|---|---|
| **Direct effect of credit** | ***0.06*** | ***0.00*** | ***0.00*** |
| **Indirect effect** | | | |
| **Observed factors** | *0.52* | *-0.39* | *0.17* |
| **Unobserved factors** | *-0.56* | *0.00* | *0.00* |
| **Total Effect* = $E(y_{1i} \mid D=1) - E(y_{2i} \mid D=1)$** | ***0.03*** | ***-0.39*** | ***0.17*** |

* Total effect is the change of logarithm of production value, which is equivalent to its percentual change
Source: Own calculations using survey data

# Curriculum Vitae

**Personal**

| | |
|---|---|
| Name: | Rodrigo Saldias Quiduleo |
| Sex: | Male |
| Data of birth: | November 1st, 1968 |
| Place of birth: | Concepción, Chile |
| Nationality: | Chilean |

**Education**

| | |
|---|---|
| 1983 – 1986 | Secondary Education, Colegio San Agustín, Concepción |
| 1987 – 1991 | Universidad de Concepción<br>School of Economics and Administration<br>Major in Economics |
| 1992 – 1995 | Master of Arts in Economics.<br>ILADES – Georgetown University |
| 2004 – 2007 | Ph.D. Student<br>Georg-August University, Göttingen, Germany |

**Professional career**

| | |
|---|---|
| 2001 - 2004 | Adviser, Ministry of Agriculture |
| 1999 – 2001 | Adviser in Regional projects for CORFO (Corporación de Fomento de la Producción) |
| 1997 – 2001 | Adviser in the Foreign Investments Committee |
| 1995 – 1996 | Economic Adviser in the Per Cápita Commission, National Health Fund. |
| 1995 – 1996 | Researcher in the Project "Environment and the Working World", Oficina Internacional del Trabajo (OIT). |
| 1994 – 1995 | Researcher in the Economic Area, Corporación de Investigación y Asesoría Sindical, (CIASI). |
| 1993 – 1993 | Management Adviser in Ovalle Moore Company, Concepción |

## Academic experience

| | |
|---|---|
| 1992 – 2002 | Lecturer at several universities in Chile.<br>Universidad de Concepción, Universidad del Desarrollo, Universidad Andrés Bello, Universidad Católica del Norte, and Universidad de Talca. |