

**RELATIONSHIPS AMONG POVERTY, FINANCIAL SERVICES,
HUMAN CAPITAL, RISK COPING, AND NATURAL RESOURCES:
EVIDENCE FROM EL SALVADOR AND BOLIVIA**

DISSERTATION

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the Degree Doctor of Philosophy in the Graduate
School of The Ohio State University

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ABSTRACT

This dissertation addresses the evaluation of impact of access to credit on two different outcomes in rural households: cultivated land (and environmental degradation through erosion) and human capital formation.

Three sets of difficulties are overcome. The fungibility of funds complicates inferences about uses of loan proceeds. Theoretical predictions about the impact of credit are not unambiguous, as credit is not a homogeneous good and it plays different roles in household strategies. Empirical tests must overcome self-selection and sample selection biases.

Several channels for the impact of credit are identified. Access to credit influences land use decisions through risk-coping, liquidity, and income and wealth effects. Access to credit influences schooling decisions for children from borrowing families through income, risk-management, gender, information, and child-labor demand effects. Actual observed outcomes are the net result of these effects (some of them positive and some negative).

Using a household theoretical model and a switching regressions empirical model, panel data from El Salvador are used to test for impacts of credit rationing. A positive effect of access to credit on natural resource conservation (through the release of pressures on fragile land) is identified in this country.

Three surveys of clients of microfinance programs in Bolivia are used to infer a net positive effect of program participation on education outcomes, measured by a schooling gap. Policy dilemmas emerge from the negative impact of microfinance on child-labor demand.

Dedicated to Rocío del Pilar

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CHAPTER 1

INTRODUCTION

This dissertation contains two essays. Although each one is an independent piece, together they reflect a research agenda on which I have been working for some time. This agenda will be a platform for my research over the next years, upon my return to Colombia. The central motivation emerged from an interest in reconciling two topics relevant for broad-based and sustainable economic growth in developing countries. One relates to the rate of growth and the level of human capital formation necessary to alleviate poverty and improve the standards of living of the population. The other one relates to the sustainable use and conservation of natural resources, which are threatened and are being exhausted at alarming rates in poor countries.

Poverty is a multidimensional condition, which affects households in different ways. Two main causes of poverty are the low productivity of available household resources and the high income and consumption volatility experienced by poor households. First, a low productivity of resources is associated with limited endowments (*e.g.*, human capital, technology and knowledge, and physical capital), not well-defined property rights, and precarious access to markets (*e.g.*, markets for goods and services, financial services, labor markets, and land markets). These constraints make it difficult

for poor households to take fuller advantage of their productive opportunities. Natural resource availability becomes a “cheap” alternative, which acts as a substitute for the lack of access to other inputs. As a consequence, natural resources are used (and sometimes overused) to generate and smooth income and to smooth consumption over time.

Second, the instability of income and consumption results from the incidence of shocks and the lack of mechanisms to anticipate and cope with adverse occurrences. Due to the particular characteristics of agricultural production, including the risk of exogenous shocks, from both climate and markets, rural households are subject to income and consumption paths with great variances. The problems emerge from the lack of available mechanisms to reduce the incidence or magnitude of expected shocks (income smoothing) or to handle unexpected disturbances that have already taken place (consumption smoothing). The inability to deal efficiently with shocks may lead to the loss of productive assets and, thereby, reduce income-generating opportunities in the future. To deal with this vulnerability, households may choose strategies that generate lower but more stable returns. Traps thus emerge, as poverty leads to vulnerability to shocks and shocks breed more poverty. Similar traps may link low levels of human capital, poverty, and resource degradation.

Financial services are useful both in overcoming constraints faced by households and in risk management. These services influence household decisions and outcomes by either making it possible to exploit productive opportunities that would otherwise not be exploited or by shifting the whole set of available opportunities, making them more

productive at every level of resource use. In this way, financial services, through access to credit, means of payments, remittances, and deposit facilities, offer rural households alternatives for increasing and smoothing income and for smoothing consumption in more efficient ways than available options (such as migration, diversification and lack of specialization, or overuse of natural resources) can accomplish. The availability of financial services leads to greater efficiency in production and can play direct and indirect roles in improving education, health, and environmental conditions.

This dissertation attempts to identify the channels through which these effects may occur. In addition to the usual and challenging methodological problems typically encountered in the measurement of impact, an evaluation of the influence of financial services on human capital formation and natural resource conservation must overcome issues related to the nature of finance itself. Most prominent are the difficulties due to the fungibility of money; as a result, credit simply increases the aggregate purchasing power of the household, and one cannot infer impact simply from knowing the ostensible purpose of the loan.

Moreover, different types of credit are not a homogeneous product, and credit plays multiple roles in the management of the livelihood strategies of a rural household with a portfolio of diverse activities, with multiple sources and multiple uses of funds. Therefore, the influences of credit on complex outcomes, such as those explored here, occur through multiple channels; sometimes, these influences, as is typical in the study of substitution and income/wealth effects, may have a different sign. It is not possible, therefore, to have a definitive, unambiguous theoretical answer to these questions.

Rather, the outcome is an empirical result influenced by initial conditions, path dependency, and particular values of the parameters. This dissertation explores these complications and attempts to learn about both method and policy prescription from empirical circumstances in El Salvador and Bolivia.

Access to financial services, moreover, especially for poor rural households, is limited. Several features of financial markets make it difficult and costly for transactions to emerge and for outreach to expand. Asymmetric information and incentive incompatibility lead to adverse selection and moral hazard problems. Contracts may be hardly enforceable in some settings, due to the lack of adequate legal and judicial structures. The shortcomings of the physical and institutional infrastructure are a barrier that constrains transactions and makes them exceedingly expensive. Markets are often segmented and the presence of market power leads to credit rationing. Asset returns, cash flows, and productive opportunities in the rural sector are highly correlated, making it difficult to diversify investment and to avoid systemic shocks.

In part as a response to these shortcomings, and in part as a response to exacerbated rent-seeking efforts from multiple constituencies, governments frequently adopt distorting policies, such as ceilings on interest rates and quantitative and qualitative restrictions on credit contracts and portfolios, adding many instances of policy failure to the complexities of market failure and to the high transaction costs already observed in these markets. As a result, many rural households with attractive opportunities do not get access to credit.

Microfinance has emerged as a set of new financial technologies, able to reach segments of the population otherwise unable to gain access to financial services, as is the case with poor rural households. Some authors argue that, besides offering tools for overcoming low productivity and income instability, microfinance services may increase the effectiveness of intertemporal decisions of the household and contribute to the empowerment of women. Moreover, through delivery innovations, some microfinance organizations (MFOs) have offered their borrowers the possibility of obtaining non-formal education in diverse topics such as health and nutrition, family planning, and the importance of education. These and other financial technologies, such as the internal account of village banks, endow households with tools to overcome low productivity as well as income and consumption instability, allowing them to improve the living standards of the family.

Acknowledging these opportunities, the second essay addresses the question of whether access to microfinance induces households or allows them to improve decisions and outcomes about human capital formation within the family, specifically through the schooling and education of children. This essay is based on information from three household surveys conducted in Bolivia over the past four years, which include clients from three different MFOs: CRECER/FFH, SARTAWI, and Pro Mujer.

Increased access to education will be key in any efforts to improve the quality of rural life and the welfare of the next generation in developing countries. Microfinance programs have been among components of strategies for poverty alleviation that have attempted to address this challenge. Five channels through which access to finance may

improve human capital formation are identified and designated as income, risk-management, child-labor demand, gender, and information effects. The sign of the impacts (positive or negative) varies across channels but, in low-income countries like Bolivia, positive impacts seem to dominate negative impacts.

Based on an econometric specification that explains schooling decisions at the household level, regression models are used to examine the various determinants of schooling achievements and to make inferences about the potential influence of microfinance, through these channels, on human capital formation.

The results for Bolivia challenge usual assumptions of microfinance programs. In particular, for some ranges of household income and for some types of borrowers, access to loans has conflicting effects on school enrollment. On the one hand, loans increase the demand for education as a result of income, risk-management, gender, and information effects. On the other hand, credit-constrained households that cultivate land or operate labor-intensive microenterprises discover new demands for child labor, either for farming, working in the microenterprise, or taking care of siblings while the mothers operate the new or expanded businesses. Significant program and policy consequences are derived from these paradoxical results.

In a similar fashion, the first essay explores the relationships among poverty, access to financial services, and natural resources, in a country characterized by frequent systemic shocks. It addresses the question of whether access to finance reduces the impact of household activities on (and overexploitation of) natural resources. There is not unambiguous theoretical answer for this question. Again, the influences of credit on

uses of land for cultivation and, thereby, on environmental degradation occur through several channels. These channels are associated with (i) risk-coping effects, which reduce the precautionary demand for land for self-insurance purposes; (ii) liquidity effects which, by providing the household with an additional command over resources, lead to changes in factor proportions in agriculture and to the expansion of non-agricultural activities, and (iii) income and wealth effects, which may induce the household to acquire more land, as a way of holding the wealth accumulated as a result of the additional income earned from access to credit.

To learn about these effects, the empirical analysis is based on a panel data set from El Salvador, which includes four cross sectional surveys. The surveys were conducted at the national level, by interviewing the same rural households for their activities during 1995, 1997, 1999, and 2001.

The results from this exercise will be of major interest in El Salvador, given the incidence of particular empirical features and initial conditions of this country on outcomes for which there are theoretically inconclusive results. The ambiguity of results is identified in an extensive survey of the literature undertaken for the first essay. By shedding some light on these issues for El Salvador, the essay will be of interest to similar low-income countries as well. In particular, most of the land that the rural poor have cleared for farming in recent years in El Salvador is situated in upper watersheds, the deterioration of which represents a long-term threat to water supplies and socioeconomic progress in this country. This is also a challenging development in similar countries.

Using a dynamic rural household production approach, with uncertainty, the essay proposes a model that allows an identification of the types of variables that may influence land use decisions within the household. This model, together with the interaction between a precautionary demand for land and changes in the purchasing power available to acquire more land, reinforces the expectation of an inverse-U shape for the relationship between land use and income (Rodríguez-Meza, Southgate and González-Vega, 2004). Through changes in the cultivation of land, these processes influence natural resource degradation

By adopting a switching regression model to take care of observations from credit markets that do not clear, where there may be multiple reasons for rural households to be credit-constrained, the empirical exercise shows that the relationship between income levels and the area of land cultivated follows the pattern of an environmental Kuznets curve. This relationship is, in turn, influenced by the status of being credit rationed. The curve for non-constrained producers, with sufficient access to credit markets, shows a threshold at an income level far lower than the threshold corresponding to the curve for credit-constrained producers. This suggests that, beyond a certain threshold, improving access to credit for rural households would generally release pressures on land use, by favoring both the intensification of agriculture and the expansion of non-agricultural activities. In this sense, the development of more cost-effective lending technologies, which would make it possible to reach households so far excluded from access to financial markets, would have a positive effect, not only in

improving their opportunities to overcome poverty, but also in inducing beneficial effects on land use and in reducing natural resource degradation.

Although not directly addressed here, improvements in the supply of other financial services, such as deposit facilities, would have similar effects. Financial savings used as a precautionary reserve would allow the household to cope with risk without having to rely so much on a precautionary demand for land. Attractive financial assets are also an alternative to holding land as a form of wealth. While this dissertation has identified some influences of credit on land use and resource conservation, additional research will be needed to examine other linkages between finance and natural resource.

CHAPTER 2

LINKING POVERTY, ACCESS TO CREDIT, AND LAND USE: EVIDENCE FROM RURAL HOUSEHOLDS IN EL SALVADOR

2.1. Introduction

This essay addresses the question of whether greater access to financial services reduces the impact of household activities on –and the overexploitation of– natural resources. In particular, the essay analyzes how households subject to credit rationing from formal financial organizations face a set of constraints different from those faced by households that are non-credit rationed and that, as a consequence, the decisions about allocating land for cultivation differ between these two groups. The empirical analysis of this hypothesis is based on information from El Salvador, a country characterized by frequent systemic shocks, a high level of cumulative deforestation, and growing overuse of land already subject to high degrees of erosion.

The results show that, under a given set of circumstances, a reduction of credit rationing and of the credit constraints faced by the rural population may lead to releasing pressures on land, with expected beneficial consequences from a reduction of environmental degradation and of the resulting negative externalities. However, in other settings, increased access to credit may actually lead to an increased allocation of land to

agriculture and, eventually, to environmental degradation. The outcome depends mostly on the impact of credit, on the one hand, on the extensification of agriculture and on an expanded scale of cultivation, in contrast to its impact, on the other hand, on (i) certain forms of intensification of agriculture, (ii) the shift of the household's labor force from agricultural to non-agricultural occupations, and (iii) the reduction of the precautionary demand for land, to be used for consumption smoothing purposes.

The influence of greater access to financial services on land use and resource degradation is intimately related to poverty. Poverty is a multidimensional condition, which affects households in different ways. Two main causes of poverty are the low productivity of available household resources and the high income and consumption volatility experienced by poor households.

Financial services are useful both in overcoming the credit constraints faced by households in their efforts to increase the productivity of resources and in risk management. Financial services can affect household decisions and income levels by (i) making it possible to exploit productive opportunities that would otherwise not be exploited, (ii) shifting the whole set of available opportunities, thereby making them more productive at every level of resource use, or (iii) inducing changes in the relative intensity with which different inputs are used in production. In particular, access to financial services may lead to changes in the proportions in which natural resources and non-environmentally sensitive inputs are combined, thus contributing to natural resource conservation.

In turn, through access to credit and deposit facilities, financial services offer rural households alternatives for smoothing their income and consumption flows in more efficient ways than available alternatives (such as migration, lack of specialization, or overuse of natural resources) can accomplish. A greater availability of deposit facilities can improve processes of wealth accumulation for investment, thereby improving productive opportunities, or for precautionary reserves, thereby assisting in risk management. Besides, more efficient financial services increase the ability of households to lengthen the horizons for their long-run decisions. Longer horizons, equivalent to lower discount rates, contribute to the conservation of natural resources. While acknowledging the central role played by deposit services in these processes, this dissertation focuses on access to credit, given the formidable obstacles that must be overcome in order to provide cost-efficient credit services in the rural areas of low-income countries.

Indeed, access to financial services, especially for poor rural households, is not easy. Several features of financial markets make it difficult for these markets to work as an ideal market. Asymmetric information and incentive incompatibility lead to moral hazard and adverse selection problems. Contracts may be hardly enforceable in some settings, due to a lack of adequate legal and judicial structures. The shortcomings of physical infrastructure are a barrier that constrains transactions. Markets are often segmented and the presence of market power leads to credit rationing. Cash flows and productive opportunities in the rural sector are highly correlated, making it difficult to

diversify investment and credit portfolios. This essay addresses some of the implications of these difficulties.

2.2. Motivation

The relationship between poverty and environmental degradation in the developing world has been a topic of increasing concern and debate. Some posit the existence of a downward spiral, through which low productivity contributes to pressure on natural resources while, in turn, this pressure exacerbates poverty (World Commission on Environment and Development, 1990). Others claim that environmental damage increases as income does (Mink, 1993; Grepperud, 1996). An intermediate perspective is the idea that this relationship may be outlined as an inverted U, a shape now known as the Environmental Kuznets Curve. This notion recognizes that households at low levels of income may exert a detrimental influence on natural resource conservation but that, after some threshold, increases in income levels become environmentally beneficial (Godoy *et al.*, 1996, 1997; Pfaff, 1999; Barbier, 2001).

In addition, the relationship between income levels and natural resource use is influenced by several factors, such as degrees of integration to markets, the nature of income-generating opportunities, exposure to risk and the availability of different strategies to manage and cope with risk, household physical endowments and levels of education, and access to financial markets, among others. In particular, decisions about land use may be conditioned on degrees of access to credit.

Access to credit, however, is itself the result of the interaction of different factors. There are supply factors, such as the presence and outreach of financial institutions, given their own lending technologies. There are demand factors, such as intertemporal preferences, household endowments, and income-generating opportunities. Besides, special characteristics of credit markets, induced by policy distortions and market failures, constrain access. As a result, households may be quantity-rationed. That is, even when at a given loan price (interest rate, transaction costs and terms and conditions of the loan contract) a household is willing and able to borrow a given amount, lenders are unwilling to lend the same amount (or anything) to the household. Understanding the reasons why credit rationing emerges and its consequences on household decisions plays a key role in understanding the way in which natural resources will be used.

The relationship between access to credit and natural resource use has not been explored adequately in the literature. Deforestation rates have been the variable most frequently used in analyses of natural resource degradation, and results of the investigation of the impact of different degrees of access to credit on deforestation decisions have turned out to be ambiguous (Ozório de Almeida and Campari, 1995; Barbier and Burgess, 1996; Godoy *et al.*, 1996, 1997; Andersen, 1997; Angelsen and Kaimowitz, 1999; Pfaff, 1999).

These results may reflect two opposing influences at work. On the one hand, access to credit would reduce deforestation if the funds were used for the intensification of agriculture on existing farmland, investment in forest management, or investment in

non-agricultural activities. On the other hand, access to credit would increase deforestation if the funds were used for clearing activities, such as increasing the amount of land for pasture, or for extensive agricultural practices. Moreover, the lack of household-level data that would allow consideration of several credit dimensions in addition to microeconomic variables may also explain the ambiguity of the empirical results observed so far.

Maybe this ambiguity is also due to the fact that credit can play more than one role in the management of the household's portfolio of activities. The fungibility of funds accentuates this dimension of the difficulties of obtaining robust results about the impact of credit on natural resource use (Adams and González-Vega, 1986). If the various influences worked in opposite directions, their impact would be an empirical issue, with no definitive theoretical answer. The question would then be, not if credit has a positive impact on resource conservation, but when it actually has this influence and under what conditions it has a negative impact.

There are several possible channels through which access to credit may affect household decisions about natural resource use. First, credit is recognized for being an effective tool to manage risk. Thus, one effect of access to credit would be a *risk-coping effect*. Consumption smoothing becomes less costly when households have access to credit. In turn, less concerns about consumption smoothing allow households to revise their production and investment decisions (Deaton, 1992). These revisions may have several effects on natural resource use. If the household feels better insured as a result of access to credit, its risk aversion to technological change will decline and, therefore, it

will move toward investment decisions that promote the intensification of agriculture. Intensification may result in released pressures on land.

This risk-coping effect may also induce the household to reduce the use of land as a precautionary asset and cultivation as a risk-coping strategy to smooth consumption over time (Rodríguez-Meza, Southgate and González-Vega, 2004). This effect would also be favorable to conservation. While one would expect a positive impact of access to credit on resource conservation through the risk-coping effect, however, under certain conditions –when other risk management strategies are already available– this influence may be negligible.

Second, access to credit generates a *liquidity effect*. Increases in the purchasing power of the household (namely, the release of the intertemporal budget constraint) lead to increased purchases of goods and inputs. What types of goods are favored by this effect will depend on the income elasticities of the demands for consumption goods and on the substitutability of different inputs and capital goods in production functions. The effects on natural resource use may differ according to the type of good purchased. For example, the household may embark on the purchase of additional capital goods either for agricultural or non-agricultural production. This will have opposite effects on land use.

On the one hand, investment in non-agricultural enterprises will lead to a release of pressures on natural resources, and a positive effect can be unambiguously identified. On the other hand, the effect of the purchase of capital goods for agricultural purposes is ambiguous. In part, it depends on the indivisibility of investment. Where the

technological package for innovation is divisible and, thereby, affordable, the intensification of agriculture can occur at any scale, even without the assistance of credit. Additional funds from the loan would simply change the scale of operation, without affecting factor proportions. A larger scale will usually have negative impacts on conservation independently of the technology used.

However, if the household faces indivisibilities in the purchase of capital goods or the technological package of inputs needed for intensification, innovation may not have occurred without credit and access to loans would lead to the desired intensification. While increases in the scale of cultivation negatively impact natural resource conservation, some forms of intensification may have a positive impact on conservation. The influence of credit thus depends on features of the production function. In particular, the forces driving the adjustment to the additional command over resources allowed by the loan are the underlying technology, as reflected in marginal rates of technical substitution, and the returns to scale that it offers.

A third potential channel of the impact of access to credit is designated as the *income and wealth effect*. If improved access to credit and the accompanying increases in income lead to wealth accumulation, this process may lead to purchases of additional land by the household. Besides its productive role and its role as a precautionary reserve, land has been associated in Latin America with social status and power. Households may invest in land as a means of social positioning. In other cases, particularly in countries with macroeconomic instability, land may be accumulated as an inflation hedge or to avoid taxes. Moreover, releasing the wealth constraint may allow the exercise of an

unsatisfied precautionary demand for land. While this demand declines with income, if there were a binding wealth constraint actual land purchases may increase with income (González-Vega *et al.*, 2004).

In some cases, this additional land may not be used for productive purposes (with a smaller impact on natural resources, except when it is deployed for consumption smoothing after adverse shocks). In other cases, it may be devoted to pastures and extensive livestock production because of the lower costs of ranching compared to crops (with a negative impact on natural resources). With additional land and livestock, the household gains social credibility as well as creditworthiness in the eyes of lenders that offer collateral-based loans. In the end, the accumulation of land allows the household additional access to credit and a new round of influences on land.

Thus, there are different channels through which access to credit may affect natural resource use. The final outcome will be the net result of these opposite forces, whose magnitude will depend on particular characteristics associated to the household, its plot of land, the degree of integration to markets, the institutional environment, and the like. This final outcome becomes an empirical issue, with no definitive theoretical answer.

This essay seeks answers about the impact of access to credit on natural resource use and about how poverty levels shape this relationship. Answers to these questions would contribute to a better understanding of household decisions on the use of credit as a tool for overcoming poverty and of the implications of these decisions on environmental degradation in developing countries.

The main hypotheses of this essay are that:

(i) the relationship between agricultural land use and the income of rural households can be represented by an environmental Kuznets curve (EKC), and that

(ii) this curve shifts upwards as a result of limited access to credit, particularly as a result of credit rationing.

The expected effects of full access to credit on the EKC, therefore, are (i) a reduction in the level of environmental degradation, at every level of income, and (ii) a reduction in the threshold level of income at which income growth begins to be environmentally beneficial. Moreover, the essay attempts to identify circumstances where these hypotheses can be rejected.

The rationale is that, with full access to credit, rural households gain additional purchasing power over market inputs for their agricultural activities and that, in this process, they substitute inputs purchased in markets for the use of natural resources. Thus, these households release pressure on the natural resources (non-market inputs) available at the fringe and used as part of consumption-smoothing strategies to deal with adverse shocks. Another expected response is an increased ability to engage in non-agricultural income-generating activities and, as a consequence, release pressures on land.

A review of several studies of the impact of credit on natural resource use (Andersen, 1997; Godoy *et al.*, 1996, 1997; Pfaff, 1999; Caviglia-Harris, 2004) suggests that the way in which credit is included in the models may explain part of the ambiguity of the results. Sometimes information about access to credit is not easily available and

proxies are used, at a cost. In the end, these proxies may not reflect access to credit correctly. This essay gains from the rich dataset available from rural household surveys in El Salvador, which makes it possible to consider a more comprehensive definition of access to credit. In particular, the essay recognizes the role that credit rationing plays in shaping the constraints that households face and how these constraints affect their decisions. To analyze the extent of credit rationing, a classification of households is proposed and is evaluated empirically.

I use data from El Salvador for the empirical test of these hypotheses. A major data gathering effort has been implemented by the Fundación Salvadoreña para el Desarrollo Económico y Social (FUSADES) and the Rural Finance Program at The Ohio State University (OSU). Since 1996, a nationally representative sample of rural households has been questioned biennially about their economic activities during the preceding calendar year. A panel of household-level data for 1995, 1997, 1999 and 2001 thus became available for empirical investigation.

In a setting such as the countryside in El Salvador, where the incidence of deforestation is massive (more than 95 percent of the country's surface is already deforested), it is expected that the marginal value that households (and society) assign to forest land is quite high. At the same time, about 70 percent of rural households still obtain energy from fuelwood, while the remaining areas covered by forest are strategic in terms of watershed protection, needed to guarantee the supply of water for a growing and highly concentrated urban population. In addition, and as a consequence of high population density, most of the land suitable for agricultural purposes is already being

used, so that decisions about increasing agricultural cultivation imply the use of plots already highly fragile, exposed to erosion, and containing the scarce reserves of biodiversity of the country. This is the main reason why, in this essay, the allocation of household land to agricultural goals is used as a measure of environmental degradation.

Next, a literature review of the relationships among poverty, natural resource use, and credit rationing is presented. After that, a theoretical approach to explain rural household decisions and to gain insights into the variables that must be considered in the empirical test is proposed. A description of the dataset used and a non-parametric analysis of the most relevant variables follow. Then, an econometric model is proposed and tested. The essay ends with conclusions and recommendations.

2.3. Review of the Literature

For the purpose of developing a framework for this essay, I will explore several areas of the literature that offer different building blocks, which will eventually converge. The first topic concerns the relationship between poverty and natural resource use; there is ample debate about ways in which limitations on income-generating alternatives may affect environmental outcomes. The second topic is related to the way in which rural households make decisions in attempts to smooth their income and consumption paths over time. I pay special attention to the role that different degrees of access to credit play in these decisions and to the impact of various types of credit rationing on production and consumption outcomes. A taxonomy of types of access to credit and a proposed approach to empirically examine the consequences are presented

at the end of this section. The third task is a review of the literature that specifically examines the impact of credit on natural resource use. Most of this work has focused on the causes of deforestation in tropical countries.

2.3.1. Poverty and Natural Resource Use

Poverty and natural resource degradation are two of the most important concerns for humankind to address in the 21st century. According to its most recent report, the United Nations Development Programme (2004) calls attention to the facts that by 2000, about 1.1 billion people (almost 20 percent of the world's population) lived at the margin of subsistence on less than one dollar a day, 831 million were undernourished, 104 million of the children of primary-education age did not attend school, 1.2 billion people did not have access to improved water sources, and 2.7 billion did not have access to adequate sanitation.

Furthermore, over half of the world's poor live in rural areas, many of them deriving their subsistence from natural resources (World Wildlife Fund, 2002). The poor depend heavily on a range of environmental goods for their livelihoods –including land, potable water, water for agriculture, fisheries, and forest products– and they suffer disproportionately when environmental conditions deteriorate or their access to these resources is limited or denied (Steele *et al.*, 2000).

For many years, the relationship between poverty and environmental degradation in the developing world has been the subject of concern and debate. One view, expressed 17 years ago by the Brundtland Commission, is that low living standards contribute to

increased pressure on natural resources, which in turn aggravates poverty (World Commission on Environment and Development, 1990). This has been the basis for arguments about the existence of a direct double-causality between poverty and resource degradation, in what has been called a "downward spiral." Contrasting with the idea of a downward spiral is the argument that, as people become more affluent, environmental damage mounts instead of diminishing (Mink, 1993; Grepperud, 1996).

To reconcile conflicting perspectives about poverty and environmental degradation, a number of economists have posited an Environmental Kuznets Curve (EKC), in reflection of the idea that economic growth may be initially detrimental for natural resources in developing countries but that, after some threshold, economic growth eventually becomes environmentally beneficial (Shafik and Bandyopadhyay, 1992; Cropper and Griffiths, 1994; Patel, Pinckney and Jaeger, 1995; Godoy *et al.* 1996, 1997; Barbier, 2001). Whether resource degradation is high or low at the peak of the curve has much bearing on the environmental consequences of economic development. Different degrees of access to credit may influence the level of this peak.

Similarly important is the income threshold beyond which economic growth and environmental quality are not just compatible but are mutually reinforcing. Cropper and Griffiths (1994), for example, find that the threshold at which the relationship between income and deforestation becomes negative is well above GDP per capita in the vast majority of African and Latin American countries with extensive tracts of tree-covered land. This finding implies that, *ceteris paribus*, development in those two continents is likely to coincide with widespread loss of natural habitats. Similar findings about the

threshold are reported by Rodríguez-Meza, Southgate and González-Vega (2004) for El Salvador.

The empirical literature addressing the causes of tropical deforestation was at an incipient stage in the early 1990s. Since then, ample use has been made of cross-national data to explore dimensions of EKC and to test various hypotheses (Kaimowitz and Angelsen, 1998). However, linkages between poverty and the conversion of natural habitats into agricultural land remain poorly understood. This is largely a consequence of limited use of household data sets, generally, and of the panel data obtained in longitudinal surveys of a sample of rural households, specifically.

In a comprehensive review of 150 empirical studies on tropical deforestation, Kaimowitz and Angelsen (1998) find that roads, higher agricultural prices, lower non-agricultural wages, and a shortage of off-farm employment generally lead to more deforestation. These authors conclude, however, that exceptions are frequent to general claims about the forces driving the loss of tree-covered habitats in the tropics. For instance, the expected effects of technical change, lower agricultural input prices, higher household income levels, and tenure security, which are generally reckoned to diminish the clearing of natural habitats, have not always been verified. Some studies have sometimes shown the opposite effects. There is a need, therefore, to learn more about circumstances where these effects can be expected and where they cannot be expected.

Godoy *et al.* (1996) state that, while many case studies of nations or regions within nations and many international comparisons show that the link between income levels and deforestation resembles an inverted U (Ruitenbeek, 1988, 1989; Lugo, 1992;

Vincent and Binkley, 1992; Hyde, Amacher and Magrath, 1993; Patel, Pinckney and Jaeger, 1995; Singh, 1994), some other authors have found weak linkages between income and deforestation or have even found evidence of a U-shaped parabola (Allen and Barnes, 1985; Rudel, 1989, 1993; World Bank, 1992; Shafik and Badyopadhyay, 1992; Cropper and Griffiths, 1994).

Responding to these findings, Barbier (2001) points out that most attempts to estimate a general EKC for agricultural land clearing have met with little success. One reason why insights are still lacking about linkages between low standards of living and deforestation is that much of the empirical literature consists of cross-country studies. Comparison of average incomes, rates of land-use change, and other national aggregates does not allow for a very nuanced examination of the causes of rural poverty, why rural households (poor and otherwise) convert forests into agricultural land, and related topics. Better insights are gained by analyzing household-level data. Other reasons for these weak results, as reviewed by Godoy *et al.* (1996), are that the available information may have not exhibited enough variance of the chief explanatory variable and that researchers may have lacked an explicit model and intermediate-level explanatory variables to link deforestation to income levels.

Surveys of rural households have been carried out to empirically examine the microeconomics of tropical deforestation. Individual choices among farming systems in northeastern Ecuador were found to be influenced by a diverse set of factors, including soil quality, tenure security, market access, and educational attainment of adult members of the household (Pichón, 1997; Pichón *et al.*, 2001). Rabindran (2002) found that land

clearing in the Bolivian Amazon is negatively related to educational attainment and off-farm wage labor.

Zwane (2002) uses panel data to analyze impacts of income change on deforestation in the Peruvian Amazon. She finds that permanent income is not differentially correlated with land clearing at the household level, although household size and access to labor markets are. Zwane concludes that creating opportunities for off-farm employment may be the best way to raise living standards while simultaneously conserving forests. Southgate (1990) also contends that improved opportunities for non-agricultural employment reduce pressure on natural habitats, as such options raise the opportunity cost of labor needed for land clearing. Bluffstone (1993), Holden (1993), Ozório de Almeida and Campari (1995), and Pichón (1997) offer empirical evidence of this linkage.

Zwane (2002) illustrates the insights to be gained from using panel data. Indeed, permanent income can be estimated only if panel data are available. Likewise, longitudinal surveying allows for examination of the impacts of positive or negative trends or shocks in income. Panel data analysis of land-use change at the household level was undertaken by Shively and Martinez (2001) in southwestern Palawan, the Philippines, where part of the sample interviewed in 1995, 1997, 1999, and 2001 comprised farm households in a lowland area. The rest of the sample was in an upland area experiencing active deforestation. Increases in the derived demand for labor resulting from a major irrigation project in the lowland area were sufficient to drive up the opportunity cost of labor at higher elevations, which encouraged a switch to farming

systems that saved labor, were more capital-intensive, and reduced agricultural land clearing (Shively, 2001).

Recently, Rodríguez-Meza, Southgate, and González-Vega (2004) estimate a recursive permanent-income model in order to test the hypothesis of the existence of an EKC for farmed area at the household level in El Salvador, using panel data for 427 households, with four biennial observations between 1995 and 2001. A first equation is used to generate a predicted value of per capita income (as a proxy for permanent income) for each one of the households and for each one of the four years of survey observations. That is, permanent income is expected to reflect the structural determinants considered in the equation, excluding random shocks, while the authors assume that perceptions about permanent income are revised every year, as these determinants change at the household level over time.

In the second equation, in which the area farmed by the household is the dependent variable, the predicted value of per capita income and the square of this predicted value were included along other explanatory variables. The coefficients for predicted per capita income and its squared value have the expected signs –positive and negative, respectively – in addition to being statistically significant. The peak of the EKC plotted with the estimated coefficients is at a level of permanent income well above what is earned by the vast majority of the households in the sample. In effect, predicted per capita incomes for more than 85 percent of the households in the sample are below the threshold at which improved living standards begin to coincide with diminished agricultural land use.

This essay builds upon the findings by Rodríguez-Meza, Southgate, and González-Vega (2004) in exploring the impact of credit rationing on the shape of the EKC. In addition, given the availability of household-level longitudinal data for the analysis, the dissertation adds to the contributions of Godoy *et al.* (1996, 1997), Pichón, (1997); Barbier (2001), Pichón *et al.* (2001), Shively and Martinez (2001), Rabindran (2002), and Zwane (2002), in an attempt to take a further step in gaining insights into the impact of access to credit on land use decisions.

2.3.2. Household Strategies and Financial Services

Rural households may adopt a number of strategies to cope with anticipated and unanticipated income fluctuations (Deaton, 1992; Morduch, 1995). *Ex post* mechanisms, such as insurance benefits, the use of accumulated financial savings, the sale of assets, and emergency loans can smooth consumption after drastic falls in income have been realized. *Ex ante* mechanisms, such as the diversification of plots, crops, and occupations, within and off the household-farm, and expected remittances from abroad, can anticipate shocks. Indeed, households may engage in diversification strategies, which are costly because of the lower productivity of labor due to more limited specialization, as they trade-off lower returns for greater income stability.

Ex ante mechanisms correspond to *income smoothing* strategies, while *ex post* mechanisms are classified as *consumption smoothing* strategies. One cannot simply look at the smoothness of consumption over time and know which type of smoothing mechanism has been at work. Indeed, the two types of mechanisms can act as

complements or substitutes for each other (Morduch, 1995). Because households adopt several kinds of both *ex ante* and *ex post* mechanisms to cope with risk, observed credit outcomes must be evaluated by simultaneously considering other risk-management options for the household. Moreover, credit may be used both as an *ex ante* and as an *ex post* instrument to manage risk.

Among alternative mechanisms for coping with adverse shocks, the cultivation of marginal land appears to be particularly costly, in terms of yields and sustainability. Adoption of this strategy may thus suggest that barriers to access to credit may exist. Poor, credit-constrained households may actually engage in environmentally-adverse risk-management strategies because they have no other alternatives in imperfect or distorted markets and incomplete institutional infrastructures.

Access to financial services matters for rural households in several ways. More efficiently offered financial services are welfare improving, among several reasons, because: (i) they reduce the costs of trading goods and resources and of participating in all markets, thereby allowing gains from trade; (ii) they allow a more efficient allocation of resources across households (when command over resources is transferred from surplus to deficit units), thereby increasing incomes; (iii) they allow households to manage and cope with risk at lower costs, with gains from more stable consumption; (iv) they facilitate the acquisition of costly capital or durable household goods (particularly when there are indivisibilities) and thereby increase productive opportunities; and, (v) by facilitating intertemporal reallocations, they allow households to achieve more

rewarding consumption paths over time (González-Vega, 1986; Adams, González-Vega and Von Pischke, 1987).

Credit markets are, however, problematic. Several difficulties create existence problems (no access), increase the costs of access, and add to other market failures. Those difficulties are related to (i) high transaction costs for both borrowers and lenders, which increase the cost of the loans beyond interest rates and depend on distance (physical, cultural, and social), (ii) information problems, which create uncertainty for the lender about the ability and willingness to repay of the borrower and may thus result in adverse selection and moral hazard, (iii) incentive problems, which emerge from the conflicting interests of lenders and borrowers and, under hidden information, may result in moral hazard, (iv) enforcement problems, which increase the costs for lenders, and (v) covariance problems, as the activities funded may be influenced by systemic shocks (González-Vega, 2003).

As a response to these difficulties, innovations in cost-effective lending technologies have adopted non-traditional approaches to collateral requirements, reducing transaction costs and barriers to access. Through these innovations, microfinance organizations and other non-traditional rural lenders have been offering mostly credit and sometimes deposit facilities to segments of the rural population otherwise without access to formal finance (Navajas and González-Vega, 2003; Rodríguez-Meza and González-Vega, 2003; Quirós, Rodríguez-Meza and González-Vega, 2003; Navajas, Conning and González-Vega, 2003). These innovations have allowed households without traditional collateral to pledge their reputation in the

community, the value in use of household goods, and the present value of their relationship with the organization –based on their future ability to generate income from their farms and microenterprises– as a guarantee on their loans. Some of these lenders have managed to rapidly expand their portfolios and keep arrears and default at very low levels.

Limited access and credit rationing continue to be, however, a main characteristic of rural credit markets in developing countries. The next section contains a more in-depth review of the credit rationing literature and its potential implications for the study of natural resource use.

2.3.3. Credit Rationing

In analyzing degrees of access to credit, I give special consideration to *credit rationing*. There has been much debate, however, about the proper definition, causes, and empirical manifestations of credit rationing.

Typically, in rural credit markets, households are not always granted the amount of credit they demand, even if they are willing to pay the going interest rate. This form of rationing may in general reflect either policy and other constraints on the setting of interest rates or the unwillingness of lenders to clear credit markets by raising interest rates. This unwillingness is mostly related to the presence of adverse selection and moral hazard.

Moreover, major difficulties for credit transactions to occur emerge from the limited and asymmetric information possessed by potential lenders from outside the rural

areas, incentive incompatibilities, and contract enforcement problems encountered when an efficient legal and judicial framework does not exist. Transactions are also simply discouraged by the high transaction costs that result from an undeveloped physical and institutional infrastructure, which do not allow borrowers and lenders to bridge the distance that separates them and that do not allow lenders to sufficiently dilute their fixed costs (González-Vega, 2003).

2.3.3.1. Defining credit rationing

To understand the mechanisms that generate rationing in a credit market, González-Vega (1984) discusses how constraints to the choice of terms and conditions of a loan contract can generate various forms of rationing. A loan has three dimensions: its size, the interest rate, and a set of terms and conditions of the contract other than the interest rate. If the interest rate is constrained for any reason, lenders have to adjust either the non-interest terms and conditions of the contract or reduce loan size. As a result, the borrower receives a combination of terms that makes the loan less attractive and lender profits decline.

If the mechanisms to clear the credit market work through the interest rate or through the non-interest terms and conditions of the loan contract, there is price rationing. In contrast, if the clearing mechanism is changes in loan size, the market is said to be quantity rationed. This is because the terms and conditions of the contract can be considered as part of the price-vector of the loan, along with the interest rate (Baltensperger, 1978). When borrowers are price rationed, they still decide whether the

price is too high or not. When borrowers are quantity rationed, in contrast, they are willing to pay the full price, with all the elements in the vector, for a given loan size but the lenders are not willing to grant that size of loan. Therefore, an unsatisfied excess demand for credit will persist at a given interest rate.

The usual assumptions from neoclassical economics lead to the concept of market clearing equilibrium, where the quantity supplied equals the quantity demanded. If the quantity demanded and the quantity supplied do not coincide, prices will adjust to the level at which the equality is restored. In this ideal scenario, quantity-rationing should not exist. Credit markets, however, may exhibit equilibria where there is excess demand for funds at equilibrium interest rates.

Credit rationing analysis dates back to the late 1950s and early 1960s. Hodgman (1960) shows that, due to the risk of default, any borrower will reach a maximum loan size beyond which she will not be able to obtain additional funds by offering to pay a higher interest rate; this happens because her wealth and repayment capacity are finite. For quantity rationing to emerge, however, an excess demand should exist, as the lender is not willing to grant the amount demanded by the borrower but offers her a smaller amount.

Jaffee (1971) demonstrates that lenders can increase expected profits by rationing some borrowers, but rationing will only occur when there is limited differentiation of interest rates. That is, when lenders charge identical interest rates to non-identical borrowers, it is profitable to supply some borrowers with a loan size smaller than that demanded at the going interest rate.

Jaffee and Russell (1976) demonstrate, in particular, how credit rationing arises as a market response to adverse selection and moral hazard. In particular, these authors analyze the behavior of a loan market in which borrowers have more information about the likelihood of default than lenders do, and they show that a stable equilibrium exists where individuals are rationed in the amount that they can borrow.

Jaffee and Russell (1976) consider two kinds of borrowers (honest and dishonest), in a two-period Fisherian consumption model. They assume that dishonest clients will default if the penalty of default is less than the contracted repayment while honest clients will not. Given that the lender observes the same demand from honest and dishonest borrowers, it does not have a mechanism to discriminate among them. The resulting equilibrium will be one with a unique interest rate and rationing for some borrowers, regardless of their honesty type.

Keeton (1979) shows that non-price rationing emerges if risk of default increases with loan size, given limited liability, or if there is a threat of moral hazard, because of the high costs of monitoring. In either case, the lender takes into account the effects of loan size and interest rate on the riskiness of the loan. Non-price rationing is a response to choices of projects and of levels of effort linked to interest rate levels.

Fried and Howitt (1980) claim that credit rationing under equilibrium conditions emerges from an agreement between borrowers and lenders to share risk. These agreements dampen movements in interest rates and lead to quantity rationing.

Stiglitz and Weiss (1981) explore the possibility of a short-run disequilibrium (as a result of stickiness in prices after exogenous shocks) and a long-run disequilibrium (as

a result of governmental constraints on interest rates). They claim that one possible reason that explains equilibrium credit markets with quantity rationing may be the presence of imperfect information and uncertainty, confirming the findings of Jaffee and Russell (1976), Keeton (1979), and Fried and Howitt (1980).

Stiglitz and Weiss (1981) show that this result emerges from the fact that the price mechanism (adjusting the interest rate) is not useful because the interest rate itself affects the riskiness of the pool of loans, by either sorting potential borrowers (adverse selection effect) or affecting the actions of borrowers (incentive effect).

Adverse selection is a consequence of borrowers with different probabilities of repayment, if lenders cannot separate good from bad credit risks, unless they use some screening device. One such screening device may be the interest rate an individual is willing to pay: those who are willing to pay high interest rates may, on average, be worse risks; they are willing to borrow at high interest rates only because they perceive their probability of repaying the loan to be low. As the interest rate rises, the average riskiness of those who borrow increases. Eventually, at a sufficiently high rate, the increased riskiness lowers profits of the lender. Alternatively, higher interest rates may induce firms to undertake projects with lower probabilities of success but with higher payoffs when successful. Again, the interest rate cannot be successfully used as a screening device and quantity rationing ensues (Stiglitz and Weiss, 1981).

At the equilibrium interest rate, the lender will not lend to an individual offering to pay more, because this loan is likely to be a worse risk than the average loan, and the market sets into equilibrium with an unsatisfied excess demand. In sum, Stiglitz and

Weiss (1981) define equilibrium non-price credit rationing as circumstances in which either (i) among loan applicants who appear to be identical, some receive loans and others do not, and the rejected applicants would not receive a loan even if they offered to pay a higher interest rate, or (ii) there are groups of individuals in the population who, with a given supply of credit, are unable to obtain loans at any interest rate even though, with a larger supply, they would. Under these circumstances, credit rationing takes the form of limiting the number of loans the lender will make, rather than limiting the size of each loan or making the interest rate charged an increasing function of loan size.

During the 1990s there was a growing literature that attempted to measure the extent and analyze the determinants of non-price rationing in credit markets (Conning, 1996; Kochar, 1997; Hauge 1998; Mushinski, 1999). As recognized by Boucher (2002), identifying the incidence of non-price rationing is important for two reasons. First, it provides an indication of the efficiency of credit markets and valuable insights into the relationship between asset distribution and credit market structure. Second, in-depth analysis of the implications of credit market structure on rural development requires a conceptual and empirical framework that identifies mechanisms that influence household access to loans. This is because the restrictions (and therefore the shadow prices) that shape investment and resource allocation decisions of farmers may be fundamentally different for price rationed versus non-price rationed households. Both reasons are valid in the context of the present essay, as outcomes about natural resource use may be shaped by the access farmers have and the constraints they face in credit markets.

The theoretical literature has focused attention on quantity types of rationing as the main non-price rationing mechanisms. Boucher and Carter (2002) suggest that this focus on quantity is too narrow. Boucher (2002) empirically examines two forms of non-interest rationing in rural credit markets in Peru: *quantity rationing*, whereby a household with a positive demand for credit is denied access, and *risk-rationing*, which occurs when a household voluntarily withdraws from the credit market for fear of losing the collateral, even though it has an expected income-enhancing investment. He also considers *transaction-costs rationing*, defined as the case where a household decides not to apply for a loan given the high transaction costs associated with it. While Boucher considers all three cases as types of non-price rationing, according to the reasoning of González-Vega (1984) the latter two are examples of price vector rationing.

Boucher (2002) tests for the empirical relevance of risk as a rationing mechanism using a multinomial logit model. He finds that access to credit markets is strongly correlated with farmer land endowments, and that quantity rationing is significantly more constraining than risk rationing. His main contribution is to draw a map of different categories of credit rationing.

2.3.3.2. Credit rationing and income distribution

The effects of credit rationing may not be uniformly distributed. González-Vega (1976) shows that interest rate ceilings and other constraints on interest-rate differentiation generate regressive redistribution effects of credit allocation, favoring better-endowed borrowers, who are not quantity rationed, and discriminating against

small, more innovative, or more risky borrowers, who are quantity rationed. As the constraints become more binding, credit concentrates in wealthier borrowers, accentuating the distribution effects of differentiated access to credit.

Ceilings on interest rates and other reasons that prevent interest-rate differentiation lead to widespread rationing but, typically, loan portfolios include both rationed and non-rationed classes of borrowers. When the constraints become more binding, the loans received by most borrowers (who are rationed) become smaller than before and than the loan size demanded at the lower rates, while a few privileged borrowers (who are not rationed) obtain all the credit they demand at the restricted rates (González-Vega, 1977). Although this differential treatment might reflect the influence of social and political power, González-Vega shows that this result can be explained by purely economic considerations related to the profit-maximization behavior of private lenders and to the survival behavior of public lenders.

When the limitations imposed on interest rates become more restrictive –due to inflation, increased lending costs, or the policy requirement of preferential rates for specific activities– the size of the loans granted to non-rationed borrowers increases while the size of the loans granted to rationed borrowers decreases. This is what González-Vega (1976) calls the *iron law of interest rate restrictions*. As the ceiling becomes lower, non-rationed borrowers move along their demand curves, demanding and receiving larger amounts of credit at the lower rate. In turn, rationed borrowers move along the lenders' marginal cost curves of granting credit to them, and the lender

grants them even smaller loans than before, although they, too, demand larger loans at the lower rate (González-Vega, 1977).

Barham, Boucher and Carter (1996) confirm these findings by showing that, especially in developing countries, non-price rationing might be common among low-wealth households. Even though their paper is aimed at analyzing whether credit unions relax non-price rationing compared to banks, for low-wealth households in Guatemala, these authors offer insights into the underlying mechanisms through which incomplete information and transaction costs may prevent interest rates from clearing formal credit markets. They find that non-price rationing by banks is common and likely to weigh most heavily on low-wealth households. They also find that, while credit unions appear to relax credit constraints for a significant portion of those rationed by banks, the poorest households are still quantity-rationed.

To illustrate that rationing is likely to be wealth biased, Barham, Boucher and Carter (1996) show that transaction costs of foreclosing on collateral in case of default include a fixed component that weighs more heavily in the case of small loan sizes. Two other reasons for wealth biases in loan markets with imperfect information arise because lenders may use wealth to distinguish the riskiness of the applicant. First, repayment capacity under a negative income shock is likely to be lower for low-wealth borrowers, because of their inability to suppress consumption to meet loan repayments and because of their inability to establish a diversified asset portfolio, inducing lenders to truncate the supply curve at a lower interest rate for poor than for rich borrowers. Second, in

inegalitarian societies, wealthier borrowers may be more visible and known to the owners and managers of lending institutions.

Barham, Boucher and Carter (1996) identify four types of loan market outcomes. The first outcome is *unconstrained*, when the borrower's demand is met. The second outcome is *transaction-costs rationing*, whose incidence is likely to be greater for low-wealth relative to high-wealth borrowers. Two other outcomes are *partial-quantity* and *full-quantity rationing*. They arise in loan markets characterized by asymmetric information. The degree of rationing depends on the ability of lending institutions to overcome information problems and reduce transaction costs. As González-Vega (2003) has argued, innovations in lending technologies reduce the incidence and bias of credit rationing.

Kochar (1997) investigates the extent of rationing in rural credit markets in India, in an effort to distinguish between the demand for credit and the lender's decision on access. From the empirical analysis, Kochar finds that the incidence of formal sector rationing is considerably less than what has been conventionally assumed.

The setting in which Kochar undertakes her analysis –subsidized formal credit for agricultural production by small households in India– leads her to suspect that rationed access to credit in favor of large farms and those in more productive regions may exacerbate existing levels of income inequality, as González-Vega (1976) argues. Moreover, a low rate of return on capital in small and fragmented farms and in regions characterized by poor infrastructure would restrict the demand for production loans, even if they were available. Further, non-participation in the formal sector would occur

if cheaper credit were available from informal sources. She argues that the extent of effective formal sector credit rationing cannot be inferred from the proportion of non-borrowing households, but that this requires knowledge of the number of households who demand formal credit but do not have access to it. That is, an identification problem must be resolved.

Kochar builds a model that considers (i) a downward-sloping demand curve for credit, (ii) an upward-sloping supply schedule for informal credit, and (iii) formal sector rationing, which generates a horizontal segment of the supply schedule for formal credit. From this specification, she defines three types of households: formal borrowers, informal borrowers, and non-borrowers. This formulation reflects formal sector rationing and optimal choices by households. Thus, non-borrowers comprise households who do not demand credit from either sector as well as those who demand formal credit but lack access to it and choose not to borrow from the informal sector.

The empirical implementation of the model, however, divides the sample into formal sector borrowers and all others. Different models used to analyze district data suggest that the demand for credit is low and that the role of credit in enhancing levels of agricultural development may be limited. The results also support the hypothesis that the reservation cost of informal credit may be less than that of formal credit for some households, further reducing the extent of effective formal sector rationing.

Most of the features that lead to non-price rationing, even without legal interest rate constraints, are present in credit markets in developing countries. Uncertainty, risk of default, transaction costs, information costs, and contract enforcement costs are

especially high in fragmented markets. Moral hazard and adverse selection may be particularly acute in the absence of appropriate lending technologies. Borrowers who are rationed by price may find credit too expensive. Such limitations of access constrain the choices made by rural households.

2.3.3.3. Empirical approaches to credit rationing

The asymmetric information problems endemic to credit transactions give rise to the potential for non-interest rationing, which make empirical analyses of credit markets challenging and conventional techniques inapplicable.

One of the main difficulties is that the researcher may not be able to infer the rationing mechanism at work just by observing the loan amount transacted. Theoretical models such as those by Gale and Helwig (1985) and Milde and Riley (1988) show that rationing may take the form of the lenders offering some applicants a loan amount that is less than that demanded at the interest rate charged. In this situation and without additional information, the researcher cannot identify whether the market has cleared for a particular borrower or if instead the supply is strictly less than the demand. If the latter holds, then loan amount serves as the rationing mechanism.

As noted in the econometrics literature on disequilibrium models, when price cannot adjust freely to clear a market, the information provided by a transaction is that the quantity transacted is the minimum of supply or demand. Although it may be incomplete, the observation of a positive loan amount does at least provide some information about demand and supply conditions for an individual. Non-borrowers, in

contrast, are more problematic. Theoretical models, derived from Stiglitz and Weiss (1981), show that quantity rationing may take the form of full rejection, so the available supply to an individual is zero at the going interest rate. In this situation, differentiating quantity-rationed borrowers, who have a positive demand at the going contract terms, from price-rationed individuals –who have zero demand– is impossible without additional information.

One option used in early empirical studies (Iqbal, 1986) is to assume that price rationing is never in effect and that, instead, all households face a binding supply constraint. Under this assumption, the observed loan amount provides full information about supply and a lower bound for an individual's demand. As pointed out by Kochar (1997), however, this approach is flawed, as it overstates the incidence of quantity rationing.

In her exploration of rural credit markets in India, Kochar points to two reasons why farmers may have no demand for formal credit. First, farmers may simply have such poor endowments that they are unable to generate rates of return that approach formal sector interest rates. This is, however, unlikely to be the case for marginal rates of return, but transaction costs may be still too high for borrowers with very small loans (González-Vega, 1980). Second, optimizing households will compare the terms of all available credit in the formal sector against those of the informal sector. Indeed, loans from friends and relatives usually carry no explicit interest rates and low rates are observed in interlinked transactions.

Variations of Kochar's model are developed by Conning (1996), Hauge (1998), and Bell, Srinivasan, and Udry (1997) –the first two in the context of Chilean and the latter in the case of Indian rural credit markets. The main difference is that their econometric models impose the assumption that informal credit is at least as expensive as formal credit. Both Conning and Hauge justify this assumption on the basis that informal interest rates usually exceeded the mean formal rate.

There are two advantages to this modified approach. First, as long as the assumption is reasonably accurate, it incorporates information that is more readily available and raises the efficiency of parameter estimates (Pudney, 1989). Second, the approach increases the degree of observable sample separation. For example, according to this assumption, a household observed with only an informal loan must be quantity rationed in the formal sector, as long as credit is homogeneous and all borrower transaction costs are added. This advantage is important because, while estimation with unobserved sample separation is possible, it is computationally demanding and – especially for small data sets– may not be feasible. Formal and informal credit may play different roles, however, and should be treated as non-homogeneous products, particularly in its role in risk management and consumption smoothing, and transaction costs differ much across borrowers and sources of credit (Adams and Nehman, 1979; Ladman, 1984; González-Vega and González-Garita, 1987)

An alternative approach is to design the survey instrument to directly collect information that permits full sample separation. Examples of this approach include Cuevas (1984), Japelli (1990), Feder *et al.* (1990), Quirós (1991), Zeller (1994),

González-Vega and Torrico (1995), Barham, Boucher and Carter (1996), González-Vega, Jiménez and Quirós (1996), Sánchez-Schwarz (1996), Mushinski (1999), Hartarska (2002) as well as the research undertaken by The Rural Finance Program at The Ohio State University in Bolivia, El Salvador and elsewhere. In this approach, households are asked qualitative questions designed to identify both supply and demand conditions and, thereby, infer the rationing mechanism in place for each individual.

2.3.3.4. The classification of types of credit rationing

In order to approximate a measure for credit rationing, Sial and Carter (1994) estimate the shadow value of capital for producers. Comparison of these shadow values with the prevailing market loan rates is expected to reflect the presence of constraints. They find evidence of credit constraints for a relatively homogeneous group of peasant grain producers in Pakistan. Barham, Boucher and Carter (1996) notice that this approach is problematic when there is heterogeneity of production activities, both within and across households, because this method requires measuring rates of return for each activity, which in turn requires detailed quantitative information on revenues, costs, and technologies.

From a different perspective, Feder *et al.* (1990) explore the latent household loan demand by asking about market experience. In particular, non-borrowing households are asked the reasons for not borrowing or their perceptions about the reasons for having been rejected. Borrowing households are asked whether they fully received the amount demanded or if they sought more credit than the amount they were

actually granted at the going rate of interest. Responses to these questions are then used to classify households as fully, partially, or unconstrained in formal credit markets. This approach has been used by OSU researchers in Costa Rica, Honduras, Russia, Mexico, and a number of African countries. Additional questions have asked about the use of complementary loans from other sources, which may also reflect quantity rationing at the original source.

One respondent group that it is problematic are those who did not apply for credit. The solution used by Kochar (1997) is to equate no application to no demand. Baydas, Meyer, and Aguilera-Alfred (1994) point out that while some non-applicants truly do not have a demand at the perceived contract rate, others who would demand a loan did not seek one because transaction costs made credit too expensive or because they believed that banks would reject them for reasons of insufficient collateral. For the case of the data from El Salvador used in this dissertation, there is enough information to discriminate among different groups, at least for two out of the four years when the survey was undertaken. Therefore, a detailed approach can be followed.

Kochar (1997) takes loan application as a signal of demand, and then estimates credit access by producers at different wealth levels. Producer households that do not apply are assumed uninterested or unconstrained. Thus, non-borrowers comprise households who do not demand credit from either sector as well as those who demand formal credit but lack access to it and choose not to borrow from the informal sector (see Figure 2.1). The empirical implementation of the model, however, divides the sample into formal sector borrowers and all others. A difficulty with her approach for non-

borrowers is that non-applicants may include wealthy producers with enough resources of their own, while rejected applicants may be severely wealth constrained.

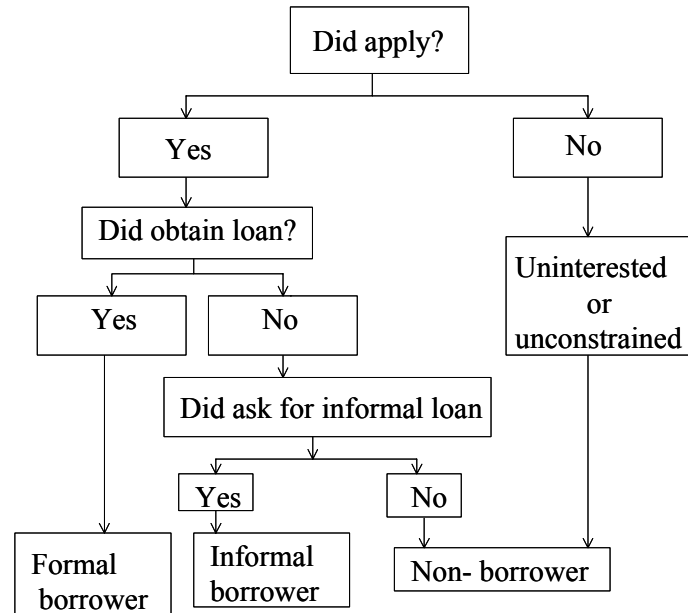


Figure 2.1. Credit rationing categories according to Kochar (1997)

Barham, Boucher and Carter (1996) group respondents into three categories (see Figure 2.2):

(a) Fully constrained: Households who either applied for a loan and were rejected or who did not apply due to

- insufficient collateral or the inability to document sufficient asset holdings to secure or collateralize the loan;

- high transaction costs; i.e., the costs of obtaining property titles, compiling data on enterprise projects, or paying other loan fees made the effective cost of the loan prohibitive; and,
- fear of risk; specifically, the potential loss of their wealth prevented them from pursuing a loan. According to these authors, this group was included among those fully constrained on the presumption that the absence of insurance or other risk-reducing mechanisms forced them to self-insure.

(b) Partially constrained: Households who received a loan but for less than the amount requested or desired given the loan terms.

(c) Unconstrained: Households who either received the full loan demanded or had no interest in a loan.

A problem with these categories, nevertheless, is that some households may overestimate their own repayment capacity or may have an opportunistic demand for credit. This issue may be complicated by the presence in the market of lenders with subsidized programs or with weak willingness to collect their loans. Applications for loans may then not reflect a legitimate demand for credit but instead a rent-seeking effort to capture a free transfer of purchasing power (González-Vega, 2003). This approach may then overestimate the extent to which households are credit constrained.

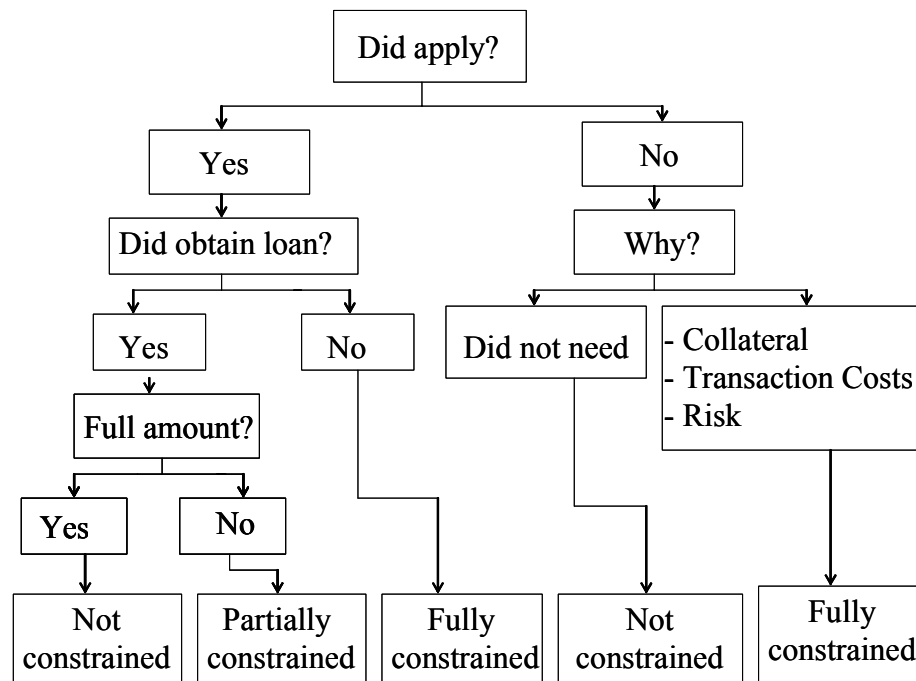


Figure 2.2. Credit rationing categories according to Barham, Boucher and Carter (1996)

Mushinski (1999) explains participation in formal credit markets in Guatemala. In addition to loan amounts, the survey asked if farmers had applied for a loan and had been rejected by a formal lender. Rejection was taken as evidence of positive demand and zero supply, so that rejected farmers were classified as quantity rationed. Mushinski further notes that, in the presence of positive transaction costs, not having been rejected may be insufficient justification for classifying a farmer as price rationed. However, transaction costs are, as claimed above, part of the price vector of the loan. Farmers who did not apply for a loan were asked why they did not seek one. A farmer was also

classified as quantity rationed if she stated that the primary reason for not applying was that she was reasonably sure she would be rejected. Mushinski calls these farmers “preemptively” rationed, since the high subjective probability of rejection accompanied by positive transaction costs leads them not to apply (see Figure 2.3). While this type of subjective questioning can greatly increase sample observability and thus efficiency of estimation, it should be pointed out that there are pitfalls as well.

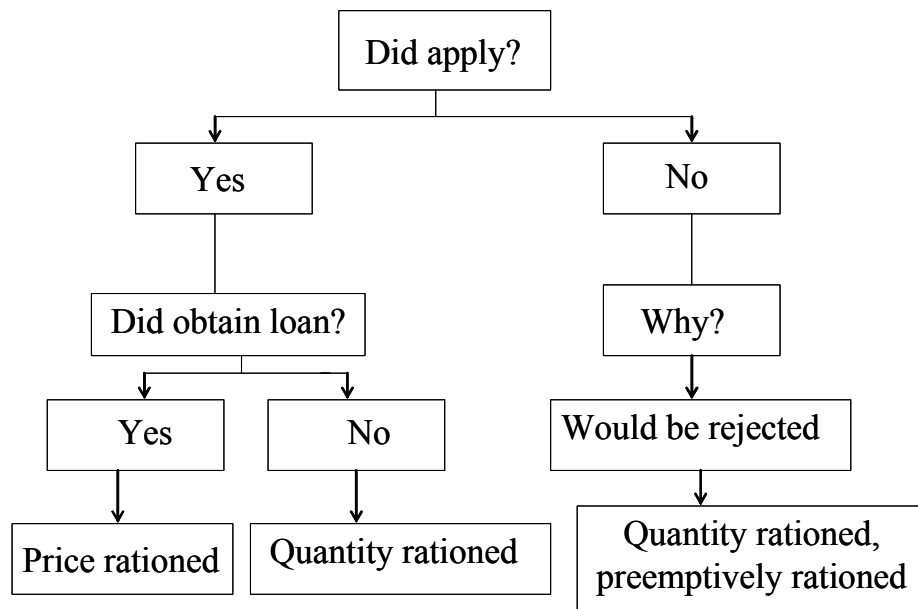


Figure 2.3. Credit rationing categories according to Mushinski (1999)

Mushinski shows that the estimation of structural parameters is sensitive to how the subjective responses are grouped. Because collecting this type of data requires the use of qualitative and sometimes hypothetical questions, it requires careful survey design

and extensive training of enumerators. Such careful preparation was implemented in the El Salvador survey used in this dissertation.

Boucher (2002) points out that the earlier approaches considered only price and quantity rationing, building on the assumption that farmers are risk neutral to simplify the econometric analysis. Thus, the derivations of demand schedules and endogenous rationing amounts are based on expected returns. The more intuitively plausible assumption of risk aversion, however, implies several important consequences. First, for a given cost, risk-averse farmers strictly prefer credit contracts that offer greater implicit insurance –or less income variability across states of nature. Second, the way lenders solve the incentive problem associated with moral hazard depends on the wealth of each borrower. As risk-rationed farmers are offered a contract, they would not be classified as quantity-rationed. To classify them as price-rationed, however, is not satisfactory. This is the reason why Boucher proposes to treat risk-rationed farmers as a separate class. Following this analysis, he proposes six categories of rationing mechanisms (see Figure 2.4):

1. Price-rationed with loan. Households that apply for a loan and receive the full amount of their application.
2. Partially quantity-rationed. Households that apply for a loan but receive less than the full amount of their application.
3. Fully quantity-rationed. Households that either apply for a loan and are rejected or do not apply because their subjective probability of rejection is too high.

4. Price-rationed without loan. Households that do not apply for a loan because the interest rate is too high.
5. Risk-rationed. Households that do not apply for a loan for fear of losing the collateral.
6. Transaction cost-rationed. Households that do not apply for a loan because the transaction costs are too high.

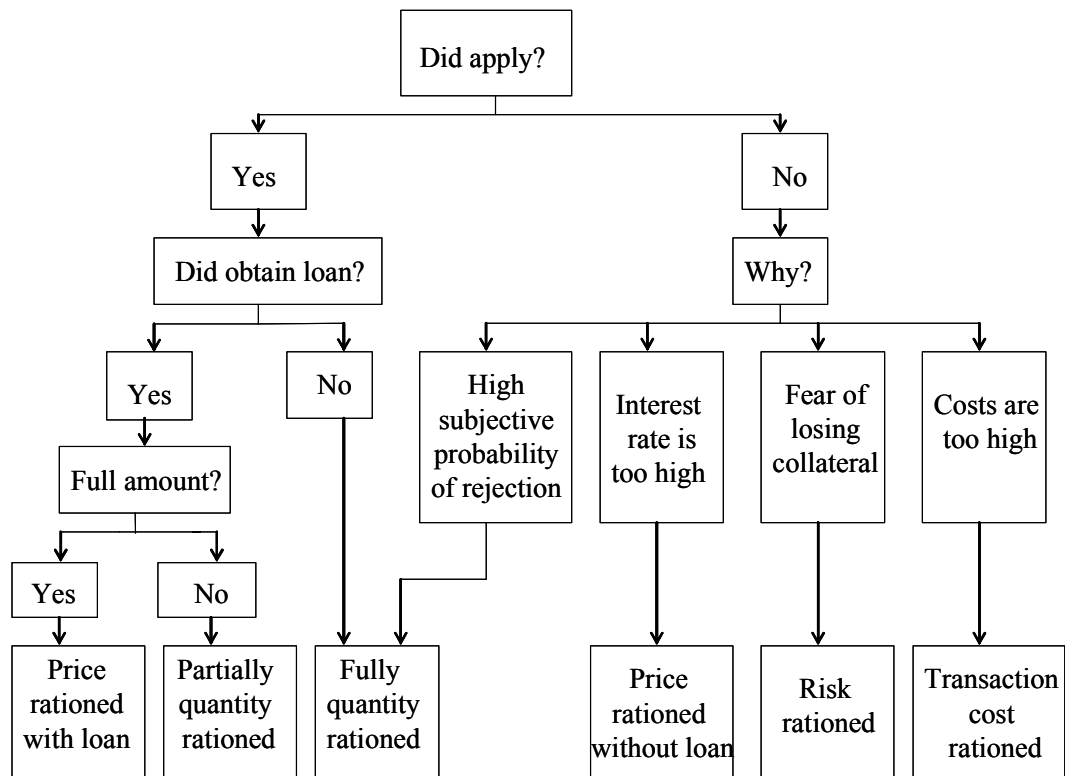


Figure 2.4. Credit rationing categories according to Boucher (2002)

The empirical verification of this classification requires that direct questions be asked to farmers. The responses may be influenced, however, by subjective value judgments. Boucher (2002) recognizes some of the issues related to the eliciting of subjective responses. First, questions should be asked with respect to a reference lender but, typically, surveys ask questions with respect to a group of institutions (commercial banks, for instance). Clearly, different formal institutions may have different lending policies, even though they are grouped under the same category. Therefore, there is a possibility that two farmers who are identical in terms of credit access would respond and be classified differently if they based their answers on different reference institutions. In the surveys for El Salvador used in this dissertation, questions were asked about specific reference lenders.

A second issue is that qualitative responses with respect to formal lenders do not explicitly control for access to other types of credit. Therefore, a household's response will reflect her best alternative, which varies across farmers. This shortcoming can be avoided if information about other sources of credit is available, as is the case for the dataset for El Salvador, where the survey asked about all sources of credit, including informal and commercial sources.

To perform econometric tests, the groups in Boucher's work are reclassified as follows:

1. Price-rationed with loan. Applied for and received some loan.
2. Price-rationed without loan. Did not apply because the interest rate was too high.

3. Risk/transaction cost-rationed. Did not apply for fear of losing the collateral or given the high level of transaction costs.
4. Quantity-rationed. Applied and was rejected or did not apply because the subjective probability of rejection was too high.

With these categories, he uses a multinomial logit model to test for the impact and characterization of households according to their status as rationed in the credit market. Boucher shows that the credit market outcomes in Piura (Peru) are strongly correlated with farmer endowments. Movements towards low collateral, low liquidity endowments rapidly raise the probability of quantity rationing. The overall explanatory power of the multinomial logit model was relatively poor and several of the estimates of the marginal impact of various wealth variables were not statistically significant for the categories of price-rationed with loan and risk rationed.

Given the information available from the datasets corresponding to the surveys for El Salvador, next I propose a new classification of households according to credit rationing, which is based in part on the previous literature and which tries to reconcile different views and approaches.

2.3.3.5. Proposed approach to credit rationing

Analysis of the impact of access to credit on household decisions should recognize the possibility that credit markets may not clear (Freeman, Ehui and Jabbar, 1998). Survey figures about the incidence of loans seem to suggest that rural households in El Salvador are prone to be credit rationed or not to have access to loans at costs

comparable to those found in other segments of the economy. Credit is rationed mostly by formal sources (commercial banks and development credit agencies). For the analysis of credit rationing here, only formal sources are considered. In section 2.5.7. I describe all the sources of credit examined.

To identify the existence of credit rationing, it is not enough to observe the presence or absence of loans. Households not using credit may not be rationed, and households using it may be rationed. Information about perceptions and actual use of credit sources must be combined. Households were surveyed as to whether they had applied for credit or not. Among those who had applied, some obtained a loan and others did not. Rejected applicants are considered here to be fully quantity rationed, although no information is available about their true creditworthiness. Those who did obtain a loan but received less than the amount they had asked for are also considered as quantity rationed, but only partially. Those who asked for a loan, obtained it, and received the amount they asked for (or more) are considered non-quantity rationed.

In turn, households who did not apply for loans are not necessarily rationed. Those who did not apply were questioned about the reasons for this decision. The answers can be grouped into four categories:

- a. *No need.* Some households claimed not to need a loan. They faced either few budget restrictions or such low-productivity opportunities that they did not require additional funds. These households are categorized here as non-quantity rationed. As in Kochar (1997), there is not enough demand.

- b. *Risk averse.* Some households claimed that to borrow is very risky, that they do not like being indebted, or that they feel uncomfortable having debt.
- c. *High cost.* In this category fall all the households that considered that loans are available, but that the contract terms are not favorable, given their own budget and preferences. Unattractive contract terms include too high interest rates, short terms to maturity, too many requirements, and so on. While these households do not truly face non-price rationing, as they simply do not want to pay prices that seem too high for them, the unresolved shortcomings of financial markets in rural areas explain the excessive cost of loan funds and exclude them from using credit in order to take advantage of opportunities with marginal rates of return equivalent to others being funded elsewhere.
- d. *Self selected out.* In this category are included all the households that think that, even if they applied, they would not obtain a loan or that lenders are not available in their region. This category groups those who consider themselves out of the credit market *a priori*.

All households in the last three sub-categories are considered as credit-constrained in some way. In contrast to Boucher (2002), I consider transaction costs as part of the price vector of the loan, as in González-Vega (1984). Therefore, households not applying because these costs are high can be considered as price-rationed instead of quantity-rationed. That is, at a given price of credit (including transaction costs), the

demand for funds goes to zero. Innovations in lending technologies that reduce these transaction costs would reduce the extent to which rural households are credit-constrained compared to other sectors of the economy (González-Vega, 2003). The proposed approach is presented in Figure 2.5.

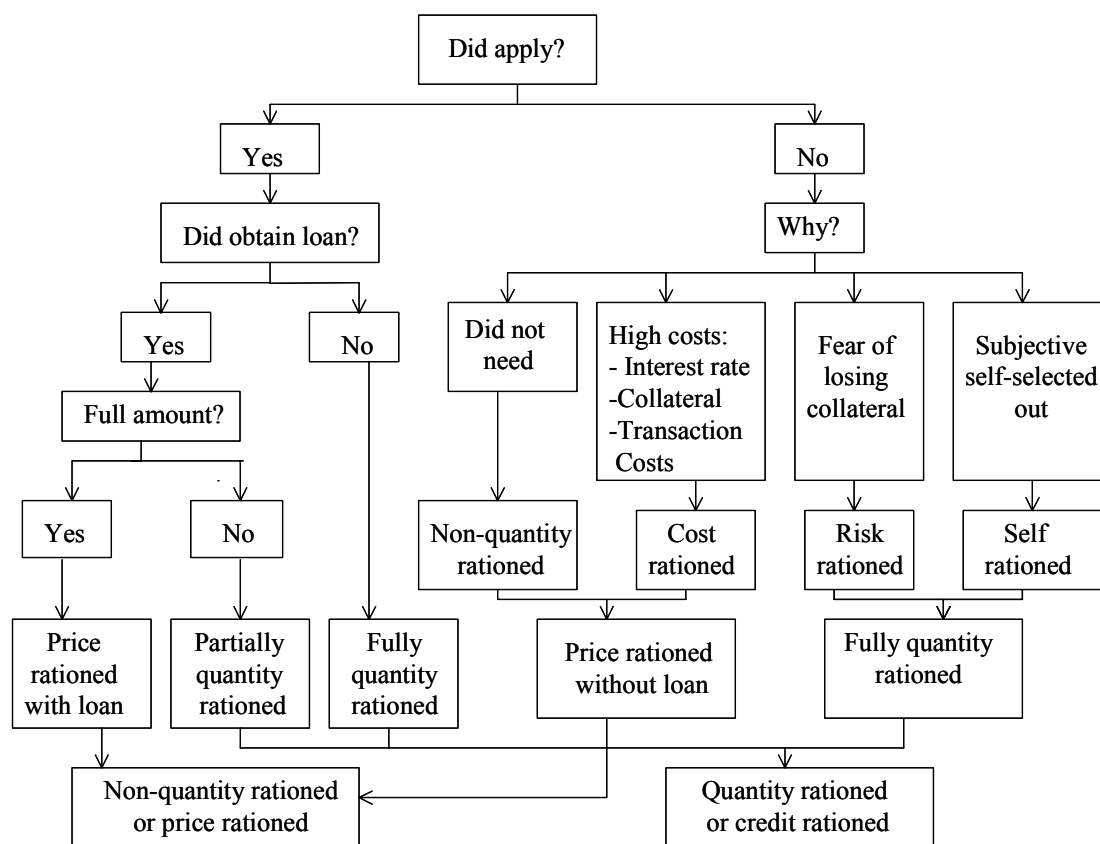


Figure 2.5. Proposed credit rationing categories

2.3.4. Access to credit and land use

In this section, I review the most relevant studies dealing with the relationship between access to credit and changes in land use, mostly deforestation, as an instance of natural resource degradation. A review of the studies that analyze the impact of credit on natural resources has shown ambiguous results. Angelsen and Kaimowitz (1998) compile the literature on economic models that examine the causes of tropical deforestation, and for the analysis of the impact of credit these authors report seven studies, six of them in tropical Latin America. Five of these studies (Ozório de Almeida and Campari, 1995; Monela, 1995; Barbier and Burgess, 1996, Andersen, 1997; Pfaff, 1999) find a direct relationship between credit availability and deforestation. The other two (Godoy *et al.*, 1996, 1997), based on indigenous farmers in Bolivia and Honduras, find that borrowers cause less deforestation.

This ambiguity may in part be attributed to the way in which access to credit is included in the models. The realization of a loan is the result of the interaction of supply and demand, the institutional framework for contract design, various dimensions of lending technologies, and other constraints from the environment. Moreover, credit is not a homogeneous good, it plays more than one role in household strategies, and one must take into account the fungibility of funds (Von Pischke and Adams, 1980). Besides, transaction costs and other terms and conditions of loan contracts affect the final outcome. As I show below, most of the studies that attempt to evaluate the impact of credit on natural resource use introduce credit through a single variable, which is an

incomplete approach and does not control for relevant distinctions about degrees of participation in credit markets. This dissertation attempts to overcome this deficiency.

For instance, one of the most frequently used variables is loan size. This variable captures some dimensions of credit rationing but others are ignored. In particular, households with a zero loan size may simply be price-rationed (that is, at a given loan price, they are not interested in acquiring debt), or they may be quantity-rationed (that is, at a given loan price, they are interested in having a loan but there is no lender interested in granting it). Households with a positive loan size may have applied for larger loans and had not been able to obtain the desired amount. Depending on these circumstances, different households with apparently similar credit access outcomes may be bound by different budget constraints or face different shadow prices, which in turn may be reflected in different natural resource use outcomes. Next, I review some of the most relevant studies on this issue, and I evaluate the pros and cons of using the variables chosen.

Andersen (1997) analyzes the effect of subsidized credit for agricultural purposes (namely, the acquisition of fertilizer, pesticide, farm equipment, and other non-land and non-labor inputs). Theoretically, he shows that in this case credit acts as a subsidy to the use of non-land, non-labor inputs. The effect of the subsidy on deforestation consists of two parts. One is an input substitution effect between forest clearing and other non-land, non-labor inputs. This effect can be direct if forest clearing and these inputs are substitutes or inverse if they are complements. That is, the outcome depends on features of the production function and marginal rates of substitution. The other one is an output

effect, which is always inverse. From a social welfare perspective, subsidized credit is found to be so beneficial for economic growth that the benefits seem to outweigh the environmental costs.

Empirically, Andersen uses as a proxy for access to credit the amount given to each municipality by the Superintendence for Amazonian Development, which was heavily subsidized credit. There is no information about other sources of credit or details about the contract terms offered by this institution.

The econometric estimation is based on a set of five equations, where the most important one refers to changes in land use (deforestation) from period to period. Andersen uses panel data for four periods (1970, 1975, 1980 and 1985) and for 316 municipalities in the Brazilian Amazon. For the tests, he tries pooled versus fixed effect regressions and decides to make inferences from a pooled regression, using OLS for each equation proposed. He finds a positive relationship between credit and rural output (that is, municipal-level agricultural gross domestic product). He also finds that credit allows investment in perennial crops, with higher profitability per hectare than annual crops (Andersen, 1996). Credit is also positively related to urban output, suggesting some fungibility of funds, which are thereby allocated to productive opportunities with higher returns than agricultural production. The credit variable is dropped from the land clearing equation due to lack of significance, which leaves the direct relationship between credit and environmental degradation unanswered.

Andersen (1997) concludes that subsidized credit tends to act as a complement of the forest, increasing the amount of deforested land. He claims that credit also

encourages urban activities, thereby increasing the rate of economic growth without being accompanied by significant deforestation. Moreover, the total welfare gain from credit was estimated to be positive, despite deforestation.

Andersen (1997) does not account for undesirable effects of subsidized credit, the implied threat of rationing, and the regressive distribution effects that emerge from this intervention in credit markets. He also ignores the monitoring costs of directed credit and the fiscal costs of the subsidy, the negative effects on depositors and taxpayers, and the incidence of these effects on other resource allocation decisions. In the absence of these considerations, the analysis of the impact of subsidized credit on welfare is incomplete and possibly misleading.

Godoy *et al.* (1997) look at household determinants of forest clearing among the Tawahka Amerindian in Honduras. Their focus on Amerindians is useful, as in this way they gain insights about household decisions on logging and clearing the forest for land use. These authors notice that the relationship between the degree of integration of households to markets and deforestation outcomes resembles an inverted U, with clearing rates peaking among households partially integrated to a market economy (Godoy, Franks and Wilkie, 1996). According to Godoy *et al.* (1997), the neotropical forest may face most pressure when households start to take an increasingly greater part in the market economy.

Empirically, these authors test for the determinants of forest clearing for land use utilizing as explanatory variables household income (that is, the imputed value of agricultural production as a proxy), duration of residence in the locality and the

household head's age, demographic variables, such as household size and educational attainment, wealth (proxied by the number of plastic buckets owned by the households and used for rubber collection), non-farm occupation, fallow lands, morbidity, amount borrowed, and rice yields.

Analyzing the behavior of cutters (namely, households that reported having cleared land) versus non-cutters, they find that the latter borrowed more from outsiders than cutters. Using a Tobit regression model, these authors find that the relationship between cutting and income exhibits an inverted U shape, that education lowers the rate of forest clearing, and that higher crop yields lower the rate of clearing. Borrowing households showed a smaller amount of primary rain forest cleared. Godoy *et al.* (1997) suggest that households with loans to repay often resort to off-farm employment and as a result have less time to clear and cultivate in the forest.

In another study, Godoy *et al.* (1996) stress the role of income growth or integration to the market in the clearing of the primary rain forest, showing that market participation simultaneously affects how a household produces, consumes, saves, and invests, all of which, in turn, affect the use of the forest. They hypothesize that the link between income and deforestation resembles an inverted U, with clearing peaking among middle-income households. As a result, forests face most pressure during the transition stage of economic development.

The fieldwork for this study was undertaken in the lowlands of the department of Beni, Bolivia, during 1995. They interviewed 200 households in 20 villages and followed an approach similar to the study undertaken in Honduras (Godoy *et al.*, 1997).

In the Bolivia study, they propose the use of individual, household, and village variables, to control for endogenous variation in income. The inclusion of a credit variable stands for a hypothesized beneficial relationship of credit on deforestation (that is, the existence of an inverse relationship). The justification is that households facing credit constraints may be forced to cut trees for sale, in order to generate liquidity, whereas household that can borrow from outsiders may have wider options for earning and smoothing income and consumption, and so they may not need to depend on the forest for these purposes as much.

Splitting the sample into cutter and non-cutter households, they analyze the effect of loan size and find that non-cutters borrowed more than twice the amount borrowed by cutters. For the econometric tests, they use a Tobit regression model and confirm the expected inverse U shape of the relationship between income and deforestation. As for the credit variable, they find some support for the hypothesis that the amount of credit obtained from lenders outside the village reduces the area of forest cleared. However, the results are not statistically significant at less than 10 percent.

Although these authors conclude that credit programs might relieve borrowing constraints and encourage households to diversify outside of forest-based activities, it is not clear that the problem of endogeneity has been resolved. The use of loan size as a measure of access to credit ignores those households that did not get loans because they did not want to. Indeed, among households with zero borrowing there may be structural differences and ignoring them may lead to the wrong conclusions.

Pfaff (1999) uses satellite and socioeconomic data to analyze determinants of deforestation in the Brazilian Amazon. He focuses on the availability of a credit infrastructure; that is, he focuses on the supply side of the credit market, to test for its importance in deforestation. He finds, however, no impact of credit infrastructure on clearing decisions. The basis for the analysis is a simple model of profit maximization, where credit conditions enter as an element of the vector of the prices of the inputs used. The author expects that credit infrastructure will increase input supply and that, as a consequence, it would lead to greater deforestation.

Empirically, Pfaff uses information from 1,970 counties in the Legal Brazilian Amazon, with satellite observations for 1975, 1978 and 1998, and with government information on socioeconomic variables. For credit supply, he uses as a proxy the number of *Banco do Brasil* branches in each county, in 1985, as well as the year when the first branch was established in each county. With this information, a credit-branch density variable is constructed for each county. Using this variable in the regression for deforestation, the infrastructure for distributing subsidized credit does not exhibit a significant effect, even though the coefficient is positive (that is, the supply of credit increases deforestation) for a pooled regression. However, in a second regression, where population is dropped from the set of explanatory variables, the effect becomes significant (and is still positive), possibly reflecting collinearity between bank branch location and population or even some endogeneity.

Pfaff tries to obtain insights from a two-stage regression but the results remain inconclusive. No panel considerations are included. The closest approach to a fixed

effects model is the use of a regression in differences. The results, however, remain as in the first model. An explanation for the high standard deviations observed may be spatial autocorrelation. As studied by several authors (Anselin, 1988; Cliff and Ord, 1981, among others) spatial analysis can carry a problem similar to that of time series: the behavior of a given unit may depend on the behavior of the units around it, creating some sort of two-dimension correlation. Techniques to perform the necessary correction are available and should be contemplated in cases like this (Anselin, 2001).

As for the variable used as a proxy for access to credit, it reflects the supply of financial services, but information about the terms of the contracts, the use of the funds, and the demand for these funds is not captured. Thus, conclusions from this study about the impact of credit on deforestation should be taken with caution.

Another feature that must be considered is that credit is subsidized and quantity rationing is likely to emerge. Ozório de Almeida and Campari (1995) show how credit in Brazil evolved from heavily subsidized in the 1970s to more free-market conditions in the 1990s. The adverse impact of subsidized credit in Brazil was demonstrated by Araujo and Meyer (1987).

Caviglia-Harris (2004) examines the practices of small-scale farmers in Rondonia, Brazil, and how agricultural production impacts deforestation levels, using a panel of 152 households interviewed in 1996 and 2000. Besides production and consumption variables, she collects information related to access to finance: the number of bank accounts held by household members and the number of bank loans received by them. Given that household information is only available for the year-2000 subsample,

she runs a particular set of regressions using just this cross section. She finds that the number of loans received by household members reduces (although not significantly) both the stock of cleared land and the percentage of land deforested. In turn, the number of bank accounts does affect land clearing, increasing deforestation. Using 2SLS for estimating crop and milk production, she finds that loans are positively correlated to the production of crops but not to milk production (although not significantly). She claims that these results suggest that access to credit can be used to promote certain production methods, (although there may be a problem of endogeneity, as lenders may prefer certain types of producers for screening and monitoring reasons) but that the final effect on deforestation might be undesirable. While the number of accounts somewhat reflects access to finance, it simultaneously reflects wealth; moreover, while number of loans reflects realizations in credit markets, this is not enough information about the extent to which a producer may be credit constrained.

This review has shown that the ambiguous results found in the literature may be explained by a number of different reasons, directly related to access to credit or not. My suggestion is to use credit rationing, as defined in section 2.2.3.5., to classify level of access to credit by households, in order to capture different dimensions of credit.

2.4. The Data

The geographic focus for the study is El Salvador, where climate and market shocks have taken a severe toll on farming. Special attention is paid to the rural poor who, because of their limited education and the high transaction costs resulting from

inadequate infrastructure, have found it difficult to compete for non-agricultural opportunities for income generation. As a result, they have shouldered most of the burden of farming's decline in this country. This has, in turn, induced many of them to devote more household labor effort and land to subsistence crop production. This response has been observed even though newly cleared fields tend to be in places where risks of erosion and other forms of environmental degradation are acute.

While El Salvador has been experiencing severe exogenous environmental and market shocks, a major data-gathering effort has been pursued by the Fundación Salvadoreña para el Desarrollo Económico y Social (FUSADES) and the Rural Finance Program at The Ohio State University (OSU). Since 1996, a nationally representative sample of rural households has been questioned biennially about their economic activities during the preceding calendar year. Thus, a panel of household-level data for 1995, 1997, 1999, and 2001 is available for empirical investigation of the relationships between poverty, household behavior, economic development in the rural areas, and the use and management of environmental resources. The construction of this panel was a component of the research agenda for the Collaborative Research Support Project on Broadening Access and Strengthening Input Market Systems (BASIS CRSP) in El Salvador implemented by FUSADES and The Ohio State University.

The surveys have been conducted at the national level, and the sample has been selected to be representative of rural households in El Salvador. The surveys have been stratified by department and occupational status: self-employed land cultivators, agricultural wage earners, and non-agricultural wage earners. The first survey was

conducted in early 1996 and asked respondents about activities during 1995. It included a base sample of 628 households and a complementary sample of 110 households needed to analyze land use but not part of the main sample. The second survey, conducted in early 1998 –asking questions about 1997 activities– included 623 households, with 493 out of them having participated in the first survey. The third survey was conducted in early 2000 and asked questions about 1999. This time the survey included 696 households. From these households, 469 had participated in the three surveys up to that date. The fourth survey was conducted in early 2002 and asked households about activities performed during 2001. This survey included 689 households. From these, 450 participated in the four surveys and 672 in the two last surveys (2000 and 2002).

The attrition was higher between the first and the second surveys than in subsequent iterations, with a loss of 135 households (21 percent of the original sample) between 1995 and 1997. These households were lost because of lack of information collected during the first survey on how to track them in the future. When the first survey was undertaken, there were no plans for additional surveys. With the second survey, the OSU team introduced the idea of constructing a panel, and the adoption of mechanisms to track properly all participants became a main objective of the exercise. In this way, attrition was reduced to very few households (24 in the third survey and 19 in the fourth survey), which implies levels of attrition of less than five percent. Most of the observations lost were households that migrated abroad, mainly to the United States. The cumulative attrition is low compared to equivalent surveys.

The amount as well as the quality of information has increased as more surveys have been undertaken. In particular, questions that allow a classification of categories of credit rationing are available for the 2000 and 2002 surveys. In this essay, the whole sample (four surveys) is used for the estimation of permanent income, in an attempt to take advantage of this rich set. For the analysis of credit rationing, however, only data from the last two surveys (2000 and 2002) is used. In addition, for the estimation of the land use decision, only households using land (either owned, rented or borrowed) were included. After dropping households not using land, the sample included 555 households with observations for the last two surveys.

Before testing the model empirically, the next sections deal with the sources and characteristics of the data available and with some statistical indicators about relevant variables.

2.5. Non-parametric Analysis

The purpose of this section is to offer a descriptive analysis of the households included in the survey samples. This description precedes the econometric tests and offers a preliminary view of potential relationships among the variables. The statistical results shown here correspond to the 1999 and 2001 surveys, and they include information about the households that had participated in the 1995 survey. From the original 628 households of the 1995 survey, 493 were surveyed in 1997. For 1999, the sample included 469 of those households and, for 2001, it included 450.

2.5.1. Income

The hypotheses of this dissertation link household income levels and area of land use. The method proposed by Rodríguez-Meza to compute annual income for the rural households in the sample is used (Rodríguez-Meza and González-Vega, 2004). The figures reported here correspond to income net of subsidies and are expressed in colones of constant purchasing power for 1999.

Average household income was 36,105 colones (equivalent to US\$ 4,126) for 2001. Average household per capita income was 6,894 colones (equivalent to US\$ 788), while average household size was 5.97 persons. Thus, in 2001 the average rural household in El Salvador had earnings above the internationally recognized poverty threshold of two dollars per day (US\$ 730 per capita per year). This average was also above the relative poverty line of 4,042 colones defined for El Salvador. Median household per capita income was 4,787 colones, which implies that less than half of the population was below the relative poverty line.

In turn, household income had been 32,412 colones (equivalent to US\$ 3,704) for 1999. Household per capita income was 6,110 colones on average (equivalent to US\$ 698), below the international threshold. Median household per capita income was 4,069 colones, while in 1999 the relative poverty line for El Salvador was 4,271 colones. For 1999, thus, more than half of the population was below the relative poverty line. Rodríguez-Meza and González-Vega (2004) report very close values of US\$ 701 for 1999 and US\$ 787 for 2001. These figures imply a high rate of growth of household per capita income, of about 6.2 percent per year for the two-year period.

In turn, Rodríguez-Meza and González-Vega (2004) report average household per capita income of US\$ 452 for 1995 and US\$ 473 for 1997. Findings by López (2000), who analyzes the data for the 1995 observation, show that per capita income was 4,040 colones or about US\$ 460. López claims that some correction may be needed for the income reported in the survey. He finds that, according to the GDP estimates for El Salvador and using information about the rural sector, the per capita income of the rural population would have been US\$560, while the survey showed it to be US\$460. This implies under-reporting of about one hundred dollars, which requires a correction of about 22 percent.

The OSU team, however, has revised the method for estimating household income and, from 1997 onwards, it has included new questions in the survey, in order to reduce the degree of underestimation. As only the figures for 1999 and 2001 will be used for the econometric estimations, the expectation in this dissertation is that the underestimation had already been reduced, while the implicit assumption is that the gap is uniform across households.

2.5.2. Poverty

Although the incidence of rural poverty declined during the 1990s in El Salvador, by the end of the century still 59 percent of the rural population was below the relative poverty line and 31 percent was below the extreme poverty line (Lardé de Palomo, 2002). In El Salvador, the extreme poverty line is set at a level of per capita income needed to purchase a diet that provides for a minimum calorie intake (the basic food

basket), and is calculated using prices for every year. The extreme poverty line was 2,135 colones for 1999 and 2,021 colones (in 1999 values) for 2001. The relative poverty line is double the level of per capita income needed to purchase one basic food basket.

Studies using the panel of rural household data also revealed wide fluctuations in income and high degrees of household mobility across the deciles of the income distribution (Beneke de Sanfeliú, 2000; Beneke de Sanfeliú and González-Vega, 2000; Rodríguez-Meza and González-Vega, 2004).

Indeed, rural households in El Salvador have experienced significant shocks in recent years. First, the country has been buffeted by environmental disturbances of great magnitude. Drought struck in 1997, when the last *El Niño* was at its peak. In early 1999, Tropical Storm Mitch unleashed torrential rains, which flooded low-lying areas and destroyed roads and bridges. Dry conditions returned in 2001, a year that began with a pair of earthquakes, while the drought-cum-floods continued in 2002. Second, even more devastating has been the steep decline in coffee prices. After peaking at \$2.00 per pound in late 1997, the international price fell to \$1.00 in 1999, and then it halved again during the following two years (Rodríguez-Meza, Southgate and González-Vega, 2004).

Despite remarkable economic growth in El Salvador during the past decade, an important share of the population is still poor. Moreover, not only does average performance matter, but the distribution of income also matters. There are different approaches to measure various dimensions of poverty, and each one of them has

advantages and disadvantages (Foster, Greer and Thorbecke, 1984; Atkinson 1987; Ravallion, 1994).

The simplest poverty measure is the *headcount index*. Here, it is measured as the proportion of households with an average per capita income below the poverty line, according to the Salvadoran standard. The international standard of two dollars per day per person differs from the poverty line defined by the Salvadoran authorities. Moreover, it does not change over time, while the latter does. In general, use of the international standard results in a higher incidence of poverty.

Figure 2.6 shows that, according to the Salvadoran criterion, the incidence of extreme poverty declined from 25 to 17 percent of the households over the two-year period, while the relative importance of the non-poor increased by almost 10 percentage points. In turn, the headcount index computed for relative instead of extreme poverty was 52 percent for the 1999 sample and 43 percent for the 2001 sample. This index, however, has the drawbacks that it does not tell about the distribution of income below the poverty line and that it does not tell about the evolution of the poverty status of particular household over time.

The dynamics of poverty matter, however. Table 2.1 shows that, among the households classified as non-poor in 1999, only 67 percent remained as non-poor in 2001, while 12 percent became extremely poor and 20 percent became relatively poor. At the same time, only 47 percent of the extremely poor in 1999 continued to be extremely poor in 2001, while 21 percent overcame poverty altogether. The condition of the relatively poor is quite volatile; over this two-year period 42 percent of them fell into

extreme poverty and 26 percent moved up to the non-poor category (Rodríguez-Meza and González-Vega, 2004).

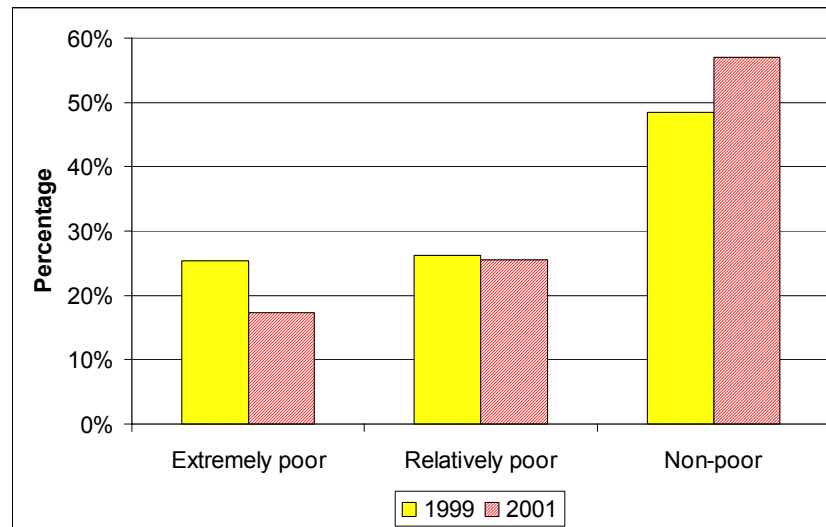


Figure 2.6. El Salvador: Distribution of the sample of rural households according to categories of poverty, using the Salvadoran poverty line, 1999 and 2001.

Summarizing, these data suggest a high degree of income volatility, which in turn implies vulnerability. The resulting limited ability to smooth income flows has negative impacts on household welfare. Being non-poor in a given period is not a guarantee for being non-poor in subsequent periods, for an important share of the rural population of El Salvador. Similarly, the poor are frequently able to escape poverty. Any analysis of rural household behavior must acknowledge the dynamics of poverty.

1999	2001			Total
	Extremely poor	Relatively poor	Non-poor	
Extremely poor	47	32	21	100
Relatively poor	42	32	26	100
Non-poor	12	20	67	100
Total	26	25	49	100

Table 2.1. El Salvador: Changes in poverty categories for the rural households in the sample, 1999 and 2001 (percentages)

The intensity and distribution of poverty also matter. To complement the headcount index there is the *poverty gap index* (PGI). This indicator is defined as the average of the ratio between the poverty gap for a household and the poverty line. In turn, the poverty gap is the difference between the poverty line and the household's level of per capita income (for those above the poverty line, the gap is zero). This index measures the depth of poverty. Using the Salvadoran poverty line for the years 1999 and 2001, the PGI was 0.27 and 0.19, respectively. This reflects a reduction in the depth of poverty. A limitation of the PGI, however, is that it does not reflect changes in the distribution of income amongst the poor.

There are several distribution-sensitive measures that reflect changes in the distribution of income amongst the poor. One such measure is the *squared poverty gap*

(SPGI), which is calculated in the same way as the PGI except that the ratios are squared before taking the mean (Ravallion, 1994). For the two years studied here, the SPGI for the sample was 0.19 for 1999 and 0.12 for 2001, showing that the reduction in the dispersion of poverty was also an important achievement in El Salvador.

Improvements did not occur, however, everywhere. Dividing the sample according to the quintiles of the per capita income distribution where the household originally fell, based on its income for 1999, changes in the index were calculated for each of these quintiles. The results are shown in Table 2.2. In general, the households in the lowest income quintile gained greater additions to income than the gains or losses of the richest households. In fact, for those in the highest income quintile in 1999, there was an average loss of income over the two-year period. Although for the sample as a whole they improved from 1999 to 2001, both the poverty gap index and the squared poverty gap index worsened for the mid, mid-high, and high income households.

Another way of evaluating the evolution of income distribution over time is to determine, for each household, the income decile to which it belonged in 1999 and then in 2001. Calculating the difference, I obtain the number of deciles that the household shifted between one year and the other. For almost 20 percent of the households there was no change in their relative position in the income distribution. About 67 percent of the households in the sample moved either up or down one or two deciles. About 10 percent of the sample moved either up or down three or four deciles. Finally, 14 percent of the sample moved either up or down more than four deciles in their location in the distribution. This confirms the presence of highly volatile income paths.

Quintile for the 1999 household						
per capita income						
Variable	Low	Mid-low	Mid	Mid-High	High	Total
Income 1999 (colones of 1999)	712	2,434	4,124	6,811	16,579	6,109
Income 2001 (colones of 1999)	3,816	4,287	5,309	7,233	13,751	6,894
Average change in income by quintile	3,104	1,853	1,185	422	-2,828	785
PGI 1999	0.83	0.43	0.08	0.00	0.00	0.27
PGI 2001	0.36	0.28	0.17	0.06	0.00	0.19
Average change in PGI	-0.47	-0.15	0.09	0.06	0.00	-0.08
SPGI 1999	0.75	0.19	0.02	0.00	0.00	0.19
SPGI 2001	0.22	0.16	0.10	0.05	0.04	0.12
Average change in SPGI	-0.53	-0.03	0.08	0.05	0.04	-0.07

Table 2.2. El Salvador: Levels and changes in household income and poverty gap indicators, over 1999-2001, according to the 1999 household per capita income quintiles in the sample.

2.5.3. Access to Basic Services

Another way of evaluating the quality of life, beyond income levels, is through an analysis of the household's access to basic services. The provision of some basic services (those examined here) either depends on conservation, such as in the case of water supplies. Alternatively, the absence of options threatens the environment, as in the case of firewood. For 2001, almost one-half of the households in the sample (48 percent) obtained drinking water from pipes, mainly internal to the house. About a quarter of the sample (26 percent) used a well, while the other quarter (26 percent) used alternative sources, such as rivers, or had to buy water from trucks. These figures show a serious problem of access to potable water, not only in terms of quantity but also in terms of quality, although there has been significant improvement since 1995 (Beneke de Sanfeliú, 2000). Future access to water in general will depend on the protection of watersheds. These findings coincide with the concerns of Panayotou, Faris and Restrepo (1997) about future availability of potable water, and those of Beneke de Sanfeliú (2002), who studied the quality of drinking water for the households in the panel.

Access to a toilet was, in the majority of the cases, through a latrine (83 percent), while 7 percent of the households in the sample had access to a common toilet in a building, and 10 percent did not have access to any kind of sanitary service in 2001.

The disposal of wastewater is most of the times inappropriate. Only 3 percent of the households had access to a sewage system; usually, wastewater was disposed of through a common latrine or a septic tank (40 and 25 percent, respectively) and in some cases to a manure latrine (8 percent). However, 25 percent of the households had to

dispose of their wastewaters in the terrain around the house or in nearby open waterway bodies.

From an environmental perspective, equally worrisome is the fact that 53 percent of the households used fuelwood as their only source of fuel for cooking. Only 6 percent of the households had access to other sources of fuel (propane gas and kerosene) and, in the end, 93 percent of the rural population used fuelwood for their cooking needs, solely or in combination with other fuels. The impact of this decision on the remaining forests is not negligible, and it is one of the main sources of concern, not only because of the high pressure on the forests but also because of the high levels of internal pollution in houses with poor ventilation.

Table 2.3 shows the use of different fuels for cooking, according to per capita income quintiles in 2001. The figures indicate that 71 percent of the households in the lowest income group used fuelwood as the only source of energy for cooking and that 98 percent used fuelwood one way or another. The pressure on fuelwood decreases as per capita income increases, but even 82 percent of the richest group uses some combination of fuelwood in their homes.

Access to basic services is precarious, and deficiencies can easily become a source of disease, which mainly affects children.

2001 household per capita income quintile						
Variable	Low	Mid-low	Mid	Mid-high	High	Total
Fuelwood	71	68	58	46	23	53
Propane	1	1	6	6	16	6
Kerosene	0	0	0	0	1	0
Fuelwood/gas	17	20	14	23	24	20
Fuelwood /kero	2	1	1	0	0	1
Gas/fuelwood	7	9	20	25	35	19
Kero /fuelwood	0	0	0	0	1	0
Other	1	0	0	0	0	0
NA	1	0	1	0	0	0

Table 2.3. El Salvador: Sources of fuel for cooking, at different household per capita income levels, 2001. (percentages)

2.5.4. Sources of Income Generation

The nature of the source of income generation plays a central role in the environmental consequences of household activities. In particular, agriculture usually puts the most pressure on resources. Extensive agriculture is more threatening than intensive agriculture for the environment. In 2001, from the total sample of 689 rural households interviewed, 450 (65 percent) engaged in agricultural activities (crops) and

430 (62 percent) in some livestock activity. Income generation according to agricultural sources, non-agricultural sources, and transfers is shown in Table 2.4. Moreover, the impact of remittances on household income in El Salvador is strong. For low-income households, remittances account for as much as 30 percent of total income. Given the high incidence of systemic shocks, remittances are a major component of household strategies to deal with risk (Pleitez-Chávez, 2004).

Equally important is to notice that non-agricultural income becomes a larger share of income as the level of income increases, ranging from an average of 39 percent for the lowest quintile to over 60 percent for the two highest quintiles. As suggested by the environmental Kuznets curve, the relationship between sources of income and land use is complex.

Salvadoran households are exposed to all kinds of adverse shocks. Dealing with risk is a major part of the story. Households that mostly depend on agricultural activities (farmers) reported that the main problem affecting crop production was drought, as 41 percent of those in the sample experienced negative impacts on agricultural yields because of the lack of rain. Other problems, such as falling prices or even the earthquakes were not cited as frequently, and affected only 6 and 1 percent of the households in the sample, respectively. For the case of livestock, while 67 percent of the producers (42 percent of the households in the sample) reported no decrease in output, 35 percent (22 percent of the households in the sample) complained about deaths, disease or weight losses of the animals during 2001. Price declines were also observed for livestock producers. Households perceived the severity of the drought less frequently

with respect to livestock than to crops. Among the sample, also 315 households produced eggs or dairy products. These activities were relatively stable during 2001, even though 20 percent of these producers reported losses.

Sources of income	2001 household per capita income quintile					Total
	Low	Mid-low	Mid	Mid-high	High	
Agricultural	2,360 (32)	6,099 (34)	7,768 (29)	9,487 (22)	18,655 (21)	8,860 (24)
Non-agricultural	2,898 (39)	7,889 (44)	13,425 (50)	25,165 (60)	55,381 (62)	20,901 (57)
Remittances and subsidies	2,118 (29)	3,971 (22)	5,713 (21)	7,530 (18)	15,241 (17)	6,903 (19)
Total income	7,376	17,959	26,906	42,182	89,278	36,664

Table 2.4. El Salvador: Income generation by main sources. Averages for rural households in 2001, in colones (percentages in parentheses)

Non-agricultural activities experienced a normal or superior performance during 2001 in 53 percent of the cases (132 out of 247 producers), while 8 percent of the households reported losses in inputs or assets, and 28 percent of them reported decreases in sales.

2.5.5. Property Rights

Home ownership is widespread, as 531 households out of 689 (77 percent) reported ownership of the house where they lived in 2001. The other 23 percent either rent (2 percent), are taking care of someone else's house (4 percent), or someone has allowed them the use of a house (11 percent), while only 6 percent of the sample reported being "colonos".

Land tenure and property rights on land show a diverse pattern. About one-half (51 percent) of the plots are owned (purchased, inherited, or obtained as a gift), and about 40 percent of them are used under other forms of tenure (renting, sharecropping, or direct borrowing). If benefits from the agrarian reform, the Peace Accords and other mechanisms (such as FINATA) are included, ownership increases to 59 percent of the plots. Only one percent of the plots are reported as "occupied".

For the sub-sample of owners, nearly 60 percent possess a public title of ownership, and more than 70 percent have some kind of documentation. The fact that the proportion of plots without any document decreases as income increases is interesting. That is, the poor are more exposed to insecurity of their property rights than the rich.

2.5.6. Precautionary Demand for Land, Land Use and Land Cover

Even though deforestation in El Salvador reached an advanced cumulative stage long ago, since the early 1990s agricultural land use has increased at the expense of tree-covered habitats. According to FAO (2000), forests in El Salvador cover at best five percent of the total land area. One fourth of the farmland shows a high degree of erosion

and loss of productivity, and about 70 percent of the population depends on firewood (Panayotou, Faris, and Restrepo, 1997).

One aspect of land clearing for agricultural purposes in places like El Salvador is puzzling at first glance. With commodity prices falling and crop yields being diminished by drought, storms, and earthquakes, one might reasonably expect farmed area to decline over time, especially if non-agricultural employment and opportunities for migration abroad have been increasing. However, precisely the opposite has been happening in El Salvador. As shown by Rodríguez-Meza, Southgate and González-Vega (2004), the key to explaining this seeming anomaly is to appreciate that, along with purely commercial demands for agricultural land, there exists a demand that is best characterized as precautionary.

The household's precautionary demand for farmland is especially pronounced in relatively bad times, when survival is particularly tenuous and more labor is devoted to subsistence farming. The cultivated portion of the household's landholding then increases. In contrast, this demand is negligible for affluent households, as they usually possess assets and access to markets –a credit line, a savings account, assets that can be sold or pawned, family remittances– that can be used to maintain consumption in the face of income shortfalls.

The relationship between income and agricultural land use is the net result of two influences. One relates to a household's demand for land, which is largely precautionary and is a decreasing function of income. The other has to do with a household's wealth, namely its purchasing power, and for this reason, access to natural resources is an

increasing function of income. For low levels of income, the first influence dominates, and many households are left with an unsatisfied willingness to cultivate more land. As their income increases, their command over resources increases and additional land is cultivated. For high levels of income, in contrast, the second influence dominates and the declining demand for cropland is binding. This behavior results in the EKC identified by Rodríguez-Meza, Southgate, and González-Vega (2004). If additions to cultivation imply the use of marginal lands, normally plots with low fertility and considerable slope and thus susceptible to erosion, then soil degradation will follow.

Around 60 percent of the plots are used for agricultural purposes (crops), with slight variations across income levels, except for the highest level, for which about 50 percent of households use land for crops. There is also a significant portion of the plots devoted to housing (see Table 2.5).

In each plot, however, land cover varies depending on the household's income. This variation can be observed in Table 2.6. The area of land devoted to crops decreases as income increases, but land area devoted to pastures increases as income does. This is a trend also observed in other Latin American countries, where landowning represents a symbol of social status for the household. Typically in these settings, as acreage increases, given income constraints, the land cover becomes more pasture-oriented. The same trend is observed for land in fallow.

Land use	2001 household per capita income quintile					Total
	Low	Mid-low	Mid	Mid-high	High	
Agriculture	67	67	61	66	54	63
Rented to others	1	2	1	2	5	2
Sharecropped by others	1	0	1	1	2	1
Urban housing	2	0	5	1	2	2
Rural housing	27	31	28	29	33	30
No use	1	0	3	1	3	2
Total	100	100	100	100	100	100

Table 2.5. El Salvador: Distribution of land use according to quintiles of household per capita income in 2001 (percentages of total area).

The share of land used by others (rented, lent to others or sharecropped by others) is largest for the highest income quintile. This may be a response to the lack of family labor for using this land in the household's own productive activities as well as to limited access to credit to finance additional projects. The limited availability of labor for additional farming may reflect a diversification of activities for consumption smoothing or to earn higher incomes in non-agricultural activities. These opportunities in non-agricultural occupations are more likely available to the households in the highest income quintile.

Land cover	2001 household per capita income quintile					Total
	Low	Mid-low	Mid	Mid-high	High	
Crops	48	45	42	41	33	41
Pastures	5	5	6	6	10	6
Forest	4	4	5	4	7	5
Fallow	1	2	1	4	3	2
Non-apt for agriculture	2	2	2	2	1	2
House	28	30	31	28	30	30
Not used	9	9	10	11	10	10
Borrowed by others	2	2	2	3	7	3
Total	100	100	100	100	100	100

Table 2.6. El Salvador: Land cover for a typical household, by quintile of household per capita income, for 2001 (percentages of total area).

2.5.7. Access to Credit

Loans can be used either for consumption smoothing or for income enhancement and smoothing. Rural households demand loans from different sources: (i) private commercial banks and other regulated financial intermediaries; (ii) non-bank intermediaries, including state-owned organizations, whose role is to assist farmers, as

well as non-profit (NGO) microfinance organizations and savings and credit cooperatives; (iii) trade-related sources, including input suppliers or crop buyers; and (iv) individuals, who either lend for profit (moneylenders) or because of a personal relationship with the household (relatives, friends, bosses, landlords and the like). The first two types are considered *formal* sources, while commercial and individual sources are considered here as *informal*.

Formal financial markets in El Salvador are thin and poorly developed, especially in the rural areas. Rodríguez-Meza (2002) found that almost two-thirds of the rural households in the sample did not have loans of any type. He also found significant segmentation between formal and informal credit markets in El Salvador, characterized by sharply different terms and conditions for different types of loans. He concluded that formal and informal loans are not a homogeneous product and that they are demanded for very different purposes. The most striking fact, however, is the limited degree of access observed.

For the period under analysis (1999-2001), almost two-thirds (63 percent) of the households did not use any type of credit, less than 1 percent used commercial banks, nearly 9 percent had access to non-bank intermediaries, around 10 percent used credit from trade-related sources, and about 17 percent used informal sources to satisfy their various demands for credit. Figure 2.7 shows the proportion of households in each quintile of the income distribution that applied for loans from any of these sources.

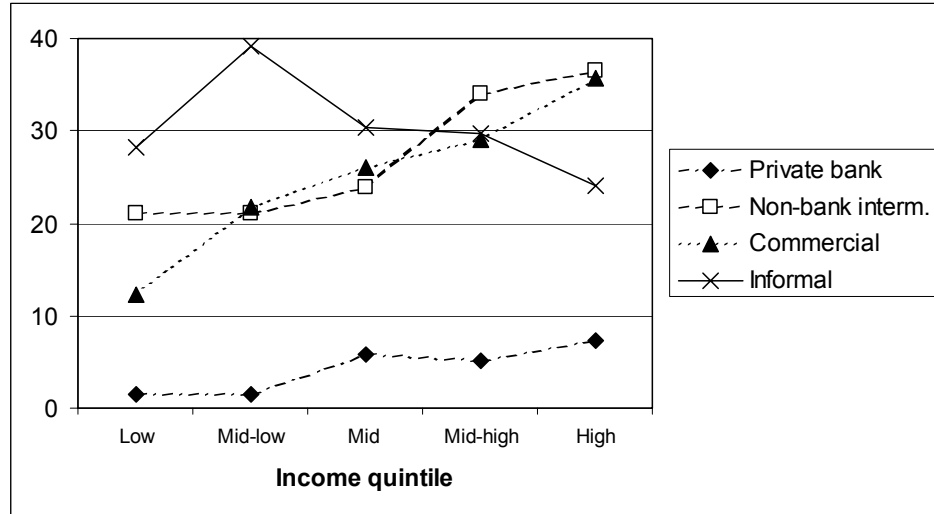


Figure 2.7. El Salvador: Loan applications by source, for the quintiles of the distribution of income, 2001 (percentages).

Private banks and regulated intermediaries are less available for rural households. Just around one percent of the two lowest income-level households have used private banks as a source of credit. Trade-related sources (commercial sources) are also relatively less frequent among low-income households, but their share grows steadily as income increases. Non-bank intermediaries reach 20 percent of the lowest income households, and their participation increases to 35 percent for the two highest income levels. This reflects how microfinance and other types of non-bank institutions, using new lending technologies –available to segments of the population excluded by private banks– reach a significant share of poor rural households. By far, however, informal lenders continue to be the source of loans for an important portion of the rural

population. These sources are the most frequently used by households in the three lowest income quintiles.

Analysis of the loans demanded during 2001 shows 374 applications, for an average amount of 2,874 colones (US\$328) and a median value of 1,000 colones (US\$114). There are some households with more than one loan application. The acceptance rate was 99 percent, with only five rejections. The loans finally granted averaged 2,637 colones (US\$301).

Reported interest rates range over a wide spectrum, from zero percent (for some informal loans) to estimates of a yearly equivalent of 716 percent. The average interest rate was 39.5 percent per year. However, if those paying zero interest are excluded from the calculations, the average interest rate increases to an equivalent of 122 percent per year.

The term to maturity of the loans granted during 2001 averages eight months (although the median is six months), ranging from three-day to five-year loans. Most loans are short-term, which may suggest that loans are used either for consumption smoothing or as part of income smoothing strategies for seasonal crops. Another plausible explanation of this outcome is that long-term loans are not offered to most rural households and an acute type of credit rationing takes place for long-term loans. As suggested by Rodríguez-Meza (2002), formal credit may be associated with income smoothing strategies while informal credit seems to be associated with consumption smoothing.

Fungibility has been recognized as a key characteristic of rural financial markets. The reported planned uses are consumption (44 percent), followed by working capital (32 percent). Different modalities of home improvements and repairs are reported as the third reason for demanding credit (22 percent). Loans planned for investment are very few.

When looking at households (rather than loans), compared against quintiles of the income distribution, interesting results are observed (Table 2.7). The average amount requested and obtained increases steadily with income. Terms to maturity increase as income does. This may reflect that low-income households demand credit for consumption smoothing while high-income households demand credit for income-generating purposes. These differences may be associated with shortcomings of supply rather than absence of demand and may reflect the various extents to which a household may be credit rationed.

Analyzing the data by the source of the loan, only 4 percent of the households in the sample had ever asked for a loan from commercial banks, while 30 percent of them asked for loans from other sources. For 2001, only two percent of the households applied to commercial banks, and almost one third of them did not obtain the loan. Most of the credit transactions were performed in the informal market (53 percent of households), where the rate of success of applications is one-hundred percent.

Variable	2001 household per capita income quintile					Total
	Low	Mid-low	Mid	Mid-high	High	
Number of observations	41	61	52	58	54	266
Proportion of households that apply (%)	30	44	38	42	39	39
Amount requested (colones)	1,197	1,835	1,898	3,449	4,801	2,703
Amount requested (US\$)	137	210	217	394	549	309
Actual loan amount (colones)	1,025	1,800	1,836	2,931	4,638	2,510
Actual loan amount (US\$)	117	206	210	335	530	287
Fees paid (colones)	180	213	94	292	375	280
Fees paid (US\$)	21	24	11	33	43	32
Fees as a proportion of the loan (%)	18	12	5	10	8	11
Annual interest rate (%)	40	57	23	32	54	41
Terms to maturity (days)	153	246	248	242	326	252

Table 2.7. El Salvador: Main variables related to access to credit by quintiles of the income distribution in 2001.

When loan characteristics are analyzed for the different sources (see Table 2.8), some interesting results emerge. The first feature is that the amount requested from banks is higher than those requested from other financial institutions, trade and informal sources. Smaller borrowers usually self-selected out and do not apply to banks, given high transaction costs and a low probability of success.

Variable	Banks	Non-bank interm.	Commercial	Informal	Total
Amount requested (colones)	10,446	6,224	3,412	1,167	2,874
Amount borrowed (colones)	2,825	5,926	3,372	1,164	2,637
Fees (colones)	286	165	294	0	0
Rate of fee deduction (%)	10	3	9	0	0
Annual interest rate (%)	46	64	29	35	39
Term to maturity (days)	510	414	248	116	247

Table 2.8. El Salvador: Loan characteristics for different credit sources, 2001.

The amounts requested from non-bank intermediaries are of medium size and are used for working capital and home repairs or improvements. At a lower end, trade sources are used to purchase inputs. Informal loan amounts are about one-tenth of bank loan amounts and one-fifth of those at non-bank intermediaries. Informal loans are most likely used for consumption smoothing, in the event of adverse shocks.

To examine the impact of access to credit on land use decisions, a comparison of land use levels and of changes between 1999 and 2001, for different types of borrowers in 2001, is presented in Table 2.9. This table includes only households that reported some land holdings. On average, all the households in the sample reduced the total area of land held and the area of land allocated to cultivation. This was not the case for the median, however. Median total holdings increased, while the median area under cultivation declined.

Moreover, in contrast, on average households without access to credit increased their total holdings and acreage under cultivation. Again, there are differences between the mean and the median, both medians declining. The reduction of the pressure on land came mostly from households with access to some kind of credit, both in terms of the mean and the median holdings and particularly of area under cultivation as well as for acreage devoted to pastures. This observation suggests that access to credit may indeed reduce the amount of land held and cultivated, possibly because households with access to credit engage more in non-agricultural activities. This result, however, has to be validated with additional control for other factors, as is accomplished by the econometric analysis below.

Type of land and year	Statistic	Type of source				Use of credit		Total
		Banks	Non-bank interm.	Com-mercial	Informal	Some credit	No Credit	
Number of observations								
1999		25	132	57	85	228	201	429
2001		20	113	105	122	259	158	418
Total area								
1999	Mean	43,742	33,961	19,967	27,050	25,966	16,530	21,545
	Median	10,563	14,155	3,619	7,336	10,563	7,042	7,923
2001	Mean	18,321	29,429	17,214	13,437	20,425	17,847	19,445
	Median	6,822	14,085	7,042	8,407	8,792	6,066	8,062
Farm land								
1999	Mean	12,793	12,512	6,948	7,123	9,361	5,618	7,607
	Median	3,472	7,582	416	3,472	6,510	3,472	3,906
2001	Mean	5,407	9,231	7,343	5,361	7,433	6,071	6,911
	Median	1,664	6,944	2,604	3,472	3,472	4,340	3,472
Pastures								
1999	Mean	15,982	9,298	5,381	7,153	6,702	3,053	4,993
2001	Mean	9,960	9,870	4,566	1,829	5,510	5,080	5,346
Forest								
1999	Mean	3,873	2,314	809	2,326	2,151	765	1,502
2001	Mean	92	1,592	858	591	1,154	922	1,066

Table 2.9. El Salvador: Household land use between 1999 and 2001, by sources of credit in 2001 (squared meters)

Increases in median land holdings are mostly associated with loans from commercial lenders. This is also true for the area under cultivation. Borrowers from commercial and informal sources were the only households that increased the area being farmed. If loans from commercial sources are associated with the acquisition of agricultural inputs, this result implies that these households engage in expansions of scale and that land and these agricultural inputs are complements.

In summary, substantial differences among borrowers from various credit sources can be observed. While borrowers using commercial and informal sources increased their median land holdings, borrowers using other sources decreased their land holdings. Loans from banks and non-bank intermediaries are frequently linked to microenterprises, which may explain the reduction in farmed area, given the household's limited labor supply. These figures suggest that there may be effects from access to credit and other financial services on decisions about land use. These effects are further explored below.

2.5.8. Credit Rationing

The most important characteristic of credit markets to be analyzed in this essay is the extent of rationing for rural households. Based on the classification proposed in section 2.3.3, an empirical validation of the categories is performed in this section. The classification is applied to outcomes from the applications for loans by households to banks and non-bank financial intermediaries, which here are referred to as formal sources.

As explained before, the sample can be divided into three groups:

1. *Fully quantity-rationed households.* This category includes households that either applied for formal credit but did not obtain it or households that did not apply but assumed that they would not be able to repay the loan (risk averse or fear of loss) or for any other reason self-selected out from the credit market.
2. *Partially quantity-rationed households.* This category includes households that applied for a formal loan and obtained it but were granted less than 80 percent of the amount they asked for. Some households received slightly lower amounts than those requested, but it would not be reasonable to consider them as particularly credit rationed.
3. *Non-quantity rationed or price-rationed households.* This category includes households that either applied for a formal loan, obtained it, and were granted the full amount they asked for (or more than 80 percent of it), or did not apply because they perceived no need of a loan or an excessively high price of the loan (including transaction costs and other indirect costs).

The analysis pertains to the 1999 and 2001 cohorts only, because the questions about perceptions on credit and attitudes by households are only available in full for these datasets. Results are shown in Figure 2.8 and Table 2.10.

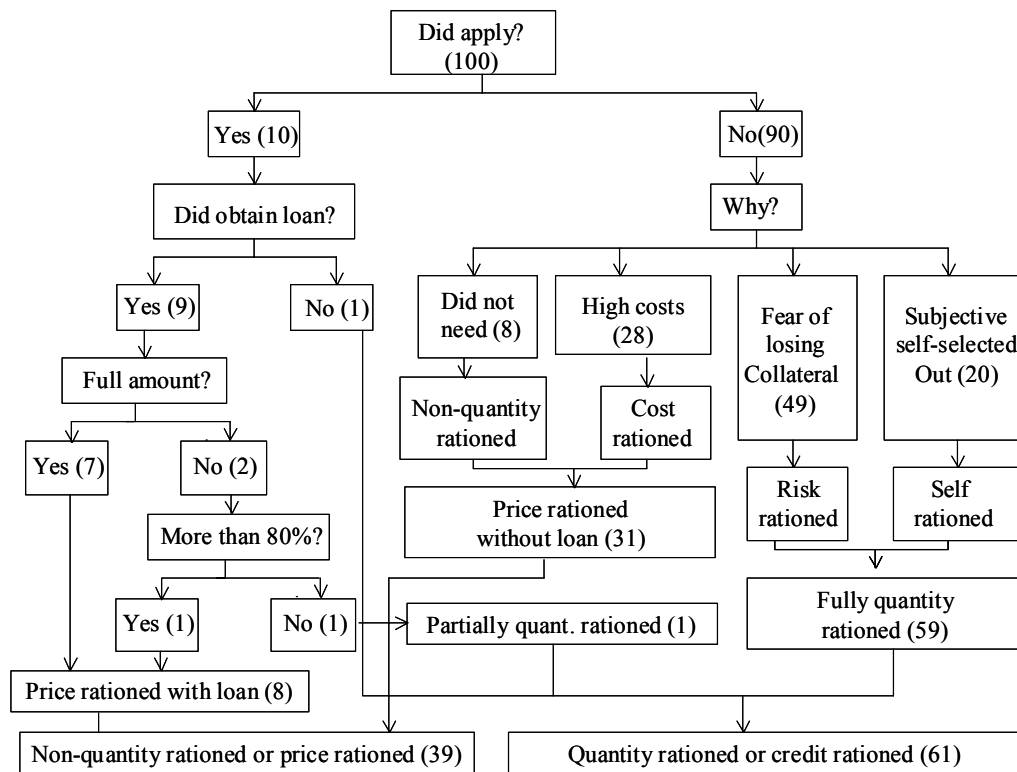


Figure 2.8. Credit rationing according to the proposed categories for households from the 1999 and 2001 cohorts (percentages in parentheses).

The impact of credit rationing on rural households in El Salvador is evident. More than half of the households can be considered as quantity rationed. Given the low presence of partially quantity-rationed households, this category is merged with the category of non-quantity rationed households when they obtained at least 80 percent of the amount requested. If the amount granted was less than 80 percent of the amount requested, the household was considered to be quantity rationed. According to Stiglitz and Weiss (1981), this is a form of quantity rationing, under the assumption that these

households did not obtain the full amount as a response from lenders to risk and uncertainty.

Level of credit rationing	1999	2001	Total panel
Non-quantity rationed	188	172	360
(price rationed)	(40)	(38)	(39)
Partially quantity rationed (less than 80 percent of request)	5	3	8
Fully quantity rationed	276	276	551
	(59)	(61)	(60)
Quantity rationed (partially and fully quantity rationed)	281	279	559
	(60)	(62)	(61)
Total households	469	451	920

Table 2.10. Credit rationing categories for households from 1999 and 2001 cohorts (percentages in parentheses).

To observe whether credit rationing is related to poverty levels, the classification is examined for the quintiles of per capita income. The results are shown in Table 2.11.

1999 household per capita income quintile						
	Low	Mid-low	Mid	Mid-high	High	Total
Non-rationed	42	27	32	30	57	188
	(45)	(29)	(34)	(32)	(61)	(40)
Rationed	52	67	62	64	36	281
	(55)	(71)	(66)	(68)	(39)	(60)
Total	94	94	94	94	93	469

Table 2.11. El Salvador: Credit rationing for households from the 1999 cohort by quintile of the household per capita income distribution (percentages in parentheses).

Table 2.11 shows that, in general, quantity rationing declines with income, and it is less frequent for the highest income group. Somewhat surprisingly, however, households in the lowest quintile exhibit a relatively low frequency of rationing. This may be explained by the fact that the poorest households might not have sufficient productive opportunities to generate a demand for credit, so they do not feel rationed.

Households in the second lowest quintile are the most affected by quantity rationing. In this group, it is likely to find households with productive opportunities and some human and physical capital but not enough to be collateralizable and, therefore,

without enough creditworthiness to be able to obtain a loan at given prices (interest rates).

Table 2.12 shows the same classification for the 2001 cohort. It reflects the same pattern as in 1999, with the difference that households in both the highest and the lowest quintile become more rationed than before and that those in the fourth quintile become less rationed. A possible explanation is that 2001 was a hard year for Salvadorans, as they faced drought and two earthquakes, while coffee prices dropped to their lowest historical levels. These occurrences may have increased the demand for funds at all income levels, for consumption smoothing. The poorest, however, were not able to obtain the loans, so the proportion of them who were rationed went up to 63 percent. Rationing did not spare the richest, nevertheless, for whom this condition went up to 53 percent. This may reflect a generalized contraction of credit supplies (Yang, 2003).

In summary, the data suggest that credit rationing varies with income. These two variables affect decisions by rural households about production and consumption and, through these decisions, about the use of natural resources, in this case land for agricultural (crop) purposes. In the next sections, a formal analysis of these relationships is presented and econometric estimation results are reported.

	2001 household per capita income quintile					Total
	Low	Mid-low	Mid	Mid-high	High	
Non-rationed	33 (37)	22 (24)	34 (38)	41 (46)	42 (47)	172 (38)
Rationed	57 (63)	68 (76)	56 (62)	49 (54)	48 (53)	278 (62)
Total	90	90	90	90	90	450

Table 2.12. El Salvador: Credit rationing for households from the 2001 cohort by quintile of the household per capita income distribution (percentages in parentheses).

2.6. The Model

After this statistical review of the most relevant variables related to poverty, access to credit, and land use in El Salvador, the next step is to define a conceptual framework that will put together the ideas for analyzing the impact of access to credit on natural resource use by rural households.

2.6.1. Modeling Rural Household Decisions

The model is based on a rural household that produces an agricultural commodity, which can be either sold in the market, consumed in the household, or both.

Production is affected by a random shock, making the outcome uncertain. In addition to the agricultural activity, the household can allocate its labor force either to a microenterprise activity –which needs a minimum amount of capital– or to off-farm employment in agricultural or nonagricultural activities.

On the consumption side, the household decides how much of the agricultural commodity, other market goods, and leisure to consume. Given that some of the decisions made by the household are inter-temporal, the model should be defined in a dynamic framework. In several aspects, the model presented here follows Roe and Graham-Tomasi's (1986) approach to dynamic modeling of agricultural households with yield risk.

The model assumes that the household has a utility function that depends on the household's level of consumption $[C_t]$ of the three goods (agricultural commodity, other market goods and leisure), given particular characteristics (*e.g.*, demographic, socioeconomic, and geographic). These characteristics also define the extent of credit rationing that the household bears. This utility function is assumed to be additively time separable. That is:

$$U = \sum_{t=0}^T \alpha^t U(C_t; \theta) = \sum_{t=0}^T \alpha^t U(Xq_t, Xm_t, Xl_t; \theta) \quad (2.1)$$

where Xq_t refers to the amount of the agricultural good consumed in period t ; Xm_t refers to the amount of the market good consumed in period t , and Xl_t refers to the amount of leisure consumed in period t . The symbol θ is used to represent the vector of characteristics of the household that, among others, define whether this household is

quantity-rationed or not in the formal credit market. The discount factor α depends on the discount rate e , namely, $\alpha=1/(1+e)$.

The household faces some constraints that should be included in the model. First, agricultural production is bounded by a production function. For simplicity, it is assumed that agricultural production depends on three factors, effort labor (L_t), the area of land devoted to agricultural activities (Aq_t), and the amount of inputs (F_t) that the household uses in agricultural production (improved seed, chemicals, fertilizer, among others). In addition, the production function is randomly affected by an exogenous shock ε_t . Convenient –but still general– assumptions about the effect of this shock on the production function are that it enters the production function multiplicatively and that the shock is identically and independently distributed over time. Then, the production function can be written as:

$$Q_t = Q(L_t, Aq_t, F_t; \varepsilon_t) = f(L_t, Aq_t, F_t)\varepsilon_t \quad (2.2)$$

Labor effort comes from either the household's labor force or hired labor. If it is assumed that the labor market works properly then, when the household decides to use a level of labor above the family's labor availability, it can hire workers in a market with a given wage rate (w_t). Alternatively, if the farming demand for labor is less than the available family labor, this excess supply can be offered in the market at the same wage rate.

The market for rural land is less efficient than the labor market. For El Salvador, being the most densely populated country in the continental Americas, the availability of land is binding for any purpose. In addition, some characteristics of this market make

frictionless transactions difficult: property rights may not be clearly defined or the transaction costs of acquiring land may be prohibitively high.

Therefore, the decision about the allocation of land for agricultural purposes is not freely determined, and it is bounded from above by the household's land holding (A_t). However, given limitations in the access to other inputs, a household may decide not to use all the available land, allocating some of the land to fallow or even forest. This unused land can also be thought of as an investment of the household, in the sense that it can be used in latter periods and that, while it is not being used, it is recovering some fertility and reducing the erosion caused by agricultural practices. In addition, some goods and services can be obtained from these unused plots, as is the case of firewood.

If the household decides to clear forest or use fallow land, this will reflect that the household needs to increase its income-generating opportunities, presumably to face shocks and cope with risk. Households use first their best-quality land, which is also the least prone to erosion and degradation. Unused land is more susceptible to environmental damage than used land because it is more fragile. As a result, strategies to face shocks and cope with risk, such as expanding agricultural activity, can be environmentally threatening.

If the household could acquire additional land, it would look for the best available land in terms of productivity. That is, it would look for good-quality plots to invest in. If the quality of these plots were better than the quality of the marginal land in their own farms, perhaps households would release some fragile land or at least would not use their remaining land for agricultural purposes. In this case, they would favorably

affect environmental quality. Due to indivisibility and land market constraints, this model is built under the assumption that the household is not able to acquire marginal land if it would decide to increase its cultivated area beyond its land endowment. The household, however, is able to sell its land –presumably the complete farm– if it were exposed to an extreme emergency. This assumption implies that even though there is a market for land, and the household may sell its farm in this market at a given land price, the possibility of purchasing marginal plots of land, as a response to shocks, is precluded.

Inputs for agricultural production are not essential. The household may have agricultural production even at a level of use of inputs of zero. The use of inputs will reflect improvements in the agricultural technology, and therefore intensification in the production process.

While land and labor for agricultural purposes can be assumed as complements (these two factors need to be used almost in constant proportions), land and inputs are substitutes. Increasing the level of agricultural intensification typically leads to reduction in the use of land for a given level of production.

Another technological constraint for the household is the microenterprise production function. The microenterprise activity requires labor effort and capital. For this model, it is assumed that labor for the enterprise can only come from the household's labor force (there is no possibility of external hiring). Denoting the labor effort allocated to the microenterprise as Hm_t and the allocation of capital as K_t , and

assuming that the microenterprise is mainly service-oriented, define M_t as the revenue derived from devoting labor and capital to the microenterprise during period t , namely:

$$M_t = M(Hm_t, K_t) \quad (2.3)$$

This revenue is measured in monetary terms. Labor effort can be allocated in perfectly divisible units, while capital cannot. First, to start a microenterprise the household needs a minimum amount of capital. Below this threshold, capital allocation is subject to indivisibility and if the household cannot afford to acquire this minimum level of capital, even having enough labor force available, it cannot engage in the microenterprise activity. Second, depending on the type of microenterprise, further expansions of the capital allocations may be subject to indivisibilities, making the production function for capital a step-wise function. For the purposes of this model, only the first indivisibility (initial investment) is adopted, under the assumption that –once the business has been established– expansions can be undertaken in marginally small allocations of labor effort and capital.

In addition to own agricultural and microenterprise revenues, the household can generate income by offering labor effort in the market. Denote as Ho_t the amount of labor allocated by the household to off-farm employment, which is remunerated with a wage rate w'_t . An implicit assumption is that $w'_t > w_t$. This assumption is based on the presumption that off-farm employment is non-agricultural in nature (*e.g.*, *maquila*), and that therefore the wage rate is higher than that obtained from agricultural activities. In a competitive labor market, this gap may reflect an implicit insurance premium, as the household may prefer to control the allocation of its labor supply, as a precaution against

shocks, even at the cost of losing off-farm income-generating opportunities. In allocating labor effort to on-farm activities, the household is guaranteeing a food safety net that prevents it from starvation under extreme shocks.

The household's labor force is constrained by family size and composition. The household has to decide how to allocate the available labor force among different activities. The total amount of labor available within the household [H_t] –the sum of working hours from household workers– has to be allocated among agricultural activities Hq_t , microenterprise labor Hm_t , off-farm activities Ho_t , and leisure Xl_t . Then

$$H_t = Xl_t + Hq_t + Hm_t + Ho_t \quad (2.4)$$

Assuming that there are prices for the agricultural good (Pq_t), market good (Pm_t), agricultural inputs (s_t), land (a_t), and labor (w_t and w'_t), the household faces a cash-income constraint given by:

$$Pm_t X m_t = Pq_t (Q_t - Xq_t) - w_t (L_t - Hq_t) - s_t F_t + M_t + w'_t Ho_t + B_t + R_t \quad (2.5)$$

where B_t refers to the demand for funds and R_t to remittances and other transfers.

Iqbal (1981) shows that although credit (formal and informal) is an important component of the demand for funds, there are other components that should be included, mainly related to internal decisions within the household. These internal decisions to satisfy the demand for funds include changes in holdings of financial assets (*i.e.*, financial savings), changes in the stock of durable goods and other physical assets (productive and non-productive), changes in livestock holdings, and changes in the allocations of land and labor. This implies that the demand for funds is the result of income and consumption strategies adopted by the household in the face of shocks and

uncertainty. In a deterministic world, the demand for funds would converge to a steady-state value for maintaining productive assets and the desired paths of income and consumption.

Remittances are an important component of total income for Salvadoran households, and they play a role both as an income and as a consumption smoothing strategy. Here, they are considered apart from the demand for funds (see Pleitez-Chávez, 2004, for a more in depth analysis of remittances to rural households in El Salvador as an strategy to deal with systemic shocks).

Financial markets are missing or incomplete in El Salvador. High transaction costs and restrictive requirements to gain access to credit (*e.g.*, collateral) make it extremely difficult for an important proportion of the rural population to obtain formal loans. This lack of access to additional purchasing power restricts their capacity to acquire marketable inputs or to adjust to intertemporal gaps in the flows of revenues and expenditures, thereby constraining the set of available opportunities for the household. Access to credit would also allow a household to choose risk-coping mechanisms not related to land overuse.

It is assumed that, given certain characteristics, some households are quantity-rationed in the credit market while others are not. There is a broad set of variables that determine this condition and even various levels of rationing but, for the purposes of this model, I assume that a household may be either quantity-rationed or not. It is important to recall that being price-rationed is a household decision that depends on preferences, endowments, and prices (including the complete price vector of the loan). In contrast,

quantity-rationed is a condition imposed upon the household as a result of its own characteristics and as a result of the structure of the credit market. For a given household, the observable variable is a binary variable that takes the value of one if the household is quantity rationed and zero otherwise.

Substituting production function (2.2) and the revenue microenterprise function (2.3) into the cash income constraint (2.4), and using the labor time constraint (2.5) to substitute for Hq_t , the restrictions can be grouped as:

$$Pm_t X m_t + Pq_t X q_t + w X l_t = Pq_t Q(L_t, Aq_t) \varepsilon_t - w_t L_t - s_t F_t + M(Hm_t, K_t) - w_t H m_t + \Delta w_t H o_t + w_t H_t + B_t + R_t \quad (2.6)$$

where the left-hand side refers to consumption expenditures and the right-hand side refers to cash income in period t . Expression Δw_t refers to the difference between the off-farm and the agriculture wage rates ($w'_t - w_t$). Full income or full purchasing power should include not only cash income but also the value of the endowment of land (A_t) and the stock of financial assets (b_t). Therefore, full income or full purchasing power can be written as:

$$Y_t = \pi_{Q_t} + \pi_{M_t} + \pi_{O_t} + w_t H_t + a_t A_t + R_t + B_t + (1+r)b_t$$

$$Y_t = \Pi_t + W_t + R_t + B_t + (1+r)b_t \quad (2.7)$$

where π_{Q_t} refers to agricultural profits, π_{M_t} refers to profits from the microenterprise, π_{O_t} refers to profits from off-farm activities, and r refers to the relevant interest rate earned or paid on financial assets and liabilities. In the second line of (2.8), Π_t represents total profits for the household (from off-farm, microenterprise, and agricultural activities) and W_t the value of total endowments. That is, full purchasing power is the aggregation of

the remunerations to productive factors, the value of endowments, transfers, and the net change in debt.

Financial asset holdings is a stock variable, and its evolution can be written as:

$$\begin{aligned}
 b_{t+1} &= Y_t - C_t - I_t \\
 &= Y_t^0 - C_t - I_t + B_t \\
 &= S_t - I_t + B_t
 \end{aligned} \tag{2.8}$$

where C_t refers to consumption expenditures, I_t to investments in capital, Y_t^0 to full income net of the demand for funds, and S_t refers to total savings for the household in period t .

The other state variable in this model is physical capital, which evolves according to the relation:

$$K_{t+1} = \delta K_t + I_t \tag{2.9}$$

where δ refers to the survival rate of capital ($\delta = 1 - \text{depreciation rate}$).

To find the solution to this system, the complete problem will be the maximization of the sum of the expected present value of utility for each period, subject to the constraints, the evolution equations, and the initial and final conditions:

$$\begin{aligned}
 &\max_{z_t} E \sum_{t=0}^T \alpha^t U(Xq_t, Xm_t, Xl_t; \theta) \\
 &\text{subject to:} \\
 &b_{t+1} = W_t + \Pi_t + (1+r)b_t - C_t - I_t + R_t + B_t \\
 &K_{t+1} = \delta K_t + I_t \\
 &b_0 = b^0; \quad K_0 = K^0; \quad b_{T+1} \geq 0; \quad K_{T+1} \geq 0 \\
 &Aq_t \leq A_t
 \end{aligned} \tag{2.10}$$

where E is the expectation operator at period zero, since the production function is randomly distributed. There are two state variables: financial assets (b) and capital (K),

with their respective evolution functions and initial and final conditions. The final conditions imply that the household does not want to leave liabilities to the following generation. The last line refers to the constraint that land for cultivation only comes from household holdings due to rigidities in the land market. The vector z_t refers to the decisions to be made by the household, and it is given by:

$$z_t = \{Xq_t, Xm_t, Xl_t, L_t, Aq_t, F_t, Hm_t, Hq_t, Ho_t, I_t, B_t; \theta\} \quad (2.11)$$

These are the control variables. Expression (2.11) implies that the household should simultaneously decide about consumption and production variables.

A value function, reflecting the maximum expected present value of utility from period t to $T+1$, starting with conditions b_t and K_t , can be expressed as:

$$V^t(b_t, K_t) = \sup_{z_t} \left[\begin{array}{l} U(Xq_t, Xm_t, Xl_t; \theta) + \alpha EV^{t+1}(b_{t+1}, K_{t+1}) \\ K_{t+1} = \delta K_t + I_t, \\ b_{t+1} = W_t + \Pi_t + (1+r)b_t - C_t - I_t + R_t + B_t, \end{array} \right] \quad (2.12)$$

Vector z_t is a plan of decisions given the state of variables b_t and K_t at every period:

$$z_t = z_t \left([b_\tau, K_\tau]_{\tau=0}^T \right) \quad (2.13)$$

Given a vector of prices p_t , an optimal plan z_t will be the solution to:

$$\max_{z_t} \{U(Xq_t, Xm_t, Xl_t; \theta) + \alpha EV_{t+1}(W_t + \Pi_t + (1+r)b_t - C_t - I_t + R_t + B_t, \delta K_t + I_t)\} \quad (2.14)$$

The first-order conditions with respect to the control (decision) variables imply the following relationships.

Consumption decisions

$$\text{With respect to } Xq_t : \quad Uq_t - Pq_t E \left(\frac{\partial V_{t+1}}{\partial b_{t+1}} \right) = 0 \quad (2.15)$$

$$\text{With respect to } Xm_t : \quad Um_t - Pm_t E \left(\frac{\partial V_{t+1}}{\partial b_{t+1}} \right) = 0 \quad (2.16)$$

$$\text{With respect to } Xl_t : \quad Ul_t - w_t E \left(\frac{\partial V_{t+1}}{\partial b_{t+1}} \right) = 0 \quad (2.17)$$

where Ui_t represents the derivative of the utility function with respect to Xi_t for $i = q, m, l$.

These three conditions imply that, as in the static framework, every period the marginal rate of substitution between the different consumption goods must equal the price ratios, namely:

$$\frac{Uq_t}{Pq_t} = \frac{Um_t}{Pm_t} = \frac{Ul_t}{w_t} \quad (2.18)$$

Production decisions

The production decisions involve choosing the amount of land devoted to agriculture, the amount of labor used in agriculture, and the allocation of family labor to the microenterprise, off-farm labor, and agriculture as well as decisions about investment and the demand for funds.

Use of land for agricultural purposes

$$\frac{dV_t}{dAq_t} = \alpha E \left(\frac{\partial V_{t+1}}{\partial b_{t+1}} \right) \left(\frac{\partial Q}{\partial Aq_t} \varepsilon_t - a_t \right) \leq 0, \quad 0 \leq Aq_t \leq A_t, \quad \frac{dV_t}{dAq_t} Aq_t = 0 \quad (2.19)$$

Demand for agricultural labor

$$\frac{dV_t}{dL_t} = \alpha E \left(\frac{\partial V_{t+1}}{\partial b_{t+1}} \right) \left(\frac{\partial Q}{\partial L_t} \varepsilon_t - w_t \right) \leq 0, \quad L_t \geq 0, \quad \frac{dV_t}{dL_t} L_t = 0 \quad (2.20)$$

These two conditions (equations 2.19 and 2.20) show how the household maximizes the expected utility derived from agricultural profits from using labor and land. Equating equations (2.19) and (2.20) results in the standard rule of equating the marginal rate of technical substitution between inputs to the input price ratio.

$$\frac{E \left(\frac{dQ}{dAq_t} \right)}{E \left(\frac{dQ}{dL_t} \right)} = \frac{a_t}{w_t} \quad (2.21)$$

Agricultural production by rural households typically exhibits fixed proportions between land for cultivation and agricultural labor. That is, these two factors behave as perfect complements.

$$\frac{Aq_t}{L_t} = \psi \quad (2.22)$$

where ψ is the fixed proportion rate of use of these two factors.

Under this assumption, solving for one of them implies solving for the other one, if ψ were known. Another way of interpreting this assumption is to assume a unique factor, denoted by T , which is the combination of labor and land used in the agricultural production.

$$T_t = Aq_t + \psi L_t \quad (2.23)$$

The value of the marginal product of this joint input, T , is a decreasing function in T (see figure 2.9).

Assuming a composite price φ_t for this composite input, under perfect market conditions, the household would choose the level of use T^* . These conditions, however, do not hold in this framework. Households have a precautionary demand for land (and thereby for on-farm agricultural labor) due to two reasons. First, the household is risk averse, specially at low levels of income and, therefore, it will prefer to guarantee some level of basic food production (a food safety net) to face shocks that could reduce income below a threshold where survival consumption is threatened.

Second, a mechanism of income smoothing to face shocks is to diversify agricultural production, in order to reduce the variance of expected returns. This diversification implies the allocation of additional land and labor for agricultural purposes.

Under these conditions, the perceived value of the marginal product of land-cum-labor shifts upward to the level $VMPT'$. This shift creates an effect with two consequences on the household's decisions. First, the perceived price of this factor declines to $\varphi_t' = \varphi_t - \sigma$. Here, σ represents the equivalent insurance premium that the household would pay but instead charges to agricultural production as a means to face risk (that is, it amounts to self-insurance). If the household had access to insurance markets or to other consumption smoothing tools, the magnitude of σ would decrease. In a perfect insurance market, σ goes to zero and the $VMPT'$ curve returns to coincide

with $VMPT$. Second, the desired level of land and labor for agricultural purposes increases to T' .

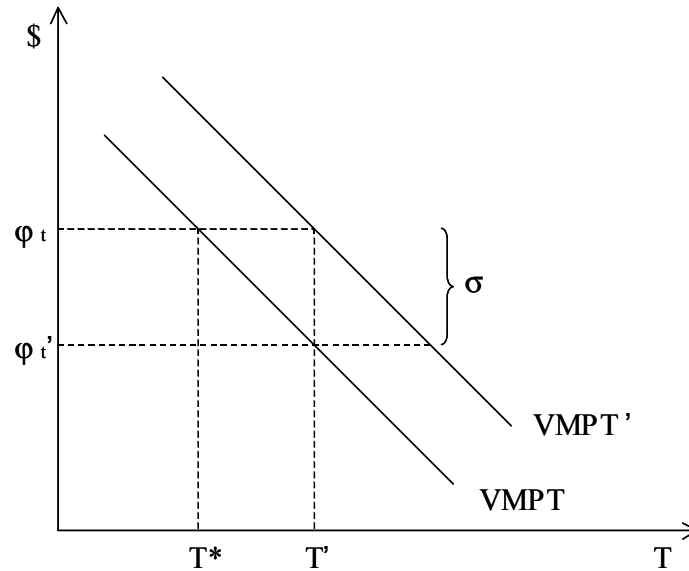


Figure 2.9. Effects of the precautionary demand for land and labor on the value of the marginal product of the composite factor.

Demand for market inputs

$$\frac{dV_t}{dF_t} = \alpha E \left(\frac{dV_{t+1}}{db_{t+1}} \right) \left(\frac{dQ}{dF_t} \varepsilon_t - s_t \right) \leq 0, \quad F_t \geq 0, \quad \frac{dV_t}{dF_t} F_t = 0 \quad (2.24)$$

Similarly, this condition shows how the household maximizes the expected utility from agricultural profits by using market inputs (improved seed, chemical, fertilizer, and

the like). A relationship between market inputs and the composite factor T can be obtained from combining equations (2.21) and (2.24):

$$\frac{E\left(\frac{dQ}{dT_t}\right)}{E\left(\frac{dQ}{dF_t}\right)} = \frac{\varphi_t}{s_t} \quad (2.25)$$

This relationship can be examined in input space (Figure 2.10). Under perfect market conditions, the household faces a budget constraint to purchase inputs (G) and would like to combine T^* and F^* to produce Q_0 units of the agricultural commodity. However, this household does not face perfect markets. On the one hand, given the existence of the risk premium (σ), the perceived price for the composite good (land and agricultural labor) is not φ_t but $\varphi_t - \sigma$, making the budget constraint turn counter clockwise on the point G/s . Therefore:

$$\frac{E\left(\frac{dQ}{dT_t}\right)}{E\left(\frac{dQ}{dF_t}\right)} = \frac{\varphi_t - \sigma}{s_t} \quad (2.26)$$

As a result, the household would like to increase its allocation of the combined factor T from T^* to T' , making agricultural production relatively more intensive in this composite factor. Market inputs in turn require cash expenses. The consequence of the lower implicit price of T will be a less market input-intensive factor proportion, which shifts from $(F/T)^0$ to (F/T') .

The magnitude of σ –and thereby the new factor proportions– depend on the availability of consumption smoothing tools for the household. Under the assumption that agricultural land expansion implies the use of more fragile land, environmental degradation will be a function of σ .

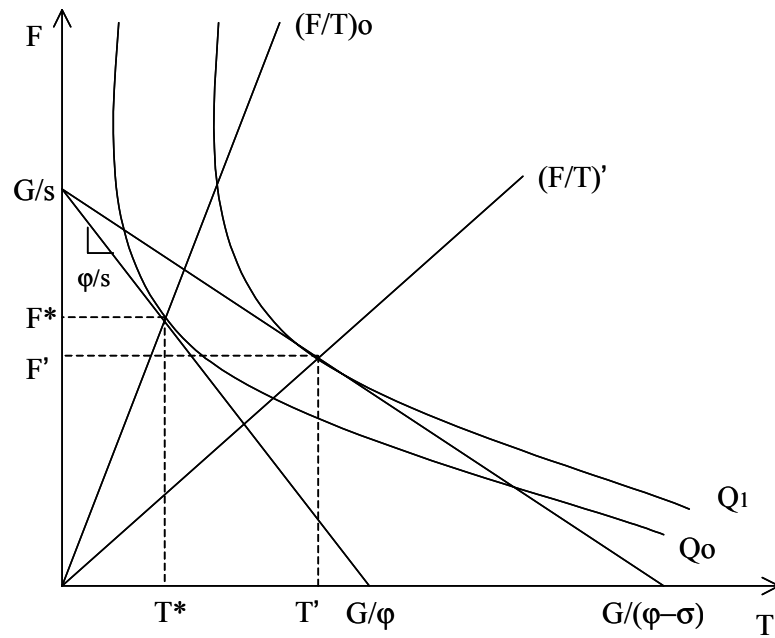


Figure 2.10. Effects of the self-insurance premium on factor proportion decisions.

Smoothing tools for the household include both credit and remittances. Greater access to credit improves access to smoothing strategies for the household and should reduce the implicit σ , therefore reducing environmental degradation. Given that some

households are credit constrained, it would be expected that these households would use more land than those non-credit constrained, *ceteris paribus*, due to this risk effect.

On the other hand, the household faces another constraint. Given their level of income, households may not be able to afford the efficient amount of market inputs and, therefore, be subject to a liquidity constraint. As shown in Figure 2.11, under a liquidity constraint the household is not able to acquire the desired F^* but only \bar{F} . This creates a shadow price of market inputs $s' > s$ that prevents condition (2.24) to be satisfied with equality. Instead

$$\frac{E\left(\frac{dQ}{dT_t}\right)}{E\left(\frac{dQ}{dF_t}\right)} = \frac{\varphi_t}{s'_t} < \frac{\varphi_t}{s_t} \quad (2.27)$$

This distortion will affect factor proportions as well. Figure 2.12 shows that, with no liquidity constraint, the household would acquire F^* units of market inputs and allocate T^* units of land-cum-labor to agricultural production. Now, given a higher shadow price for market inputs ($s' > s$), the budget constraint G will rotate counter clockwise on G/φ , changing the input proportion from $(F/T)^0$ to $(F/T)'$, creating the same effect as the self-insurance premium effect. Given market price s and budget constraint G , the household will allocate T' units of land-cum-labor and only F' units of market inputs to its agricultural production. At point B , the household does not equal the marginal rate of technical substitution between market inputs and the composite factor with the market price ratio as expected from equation (2.25).

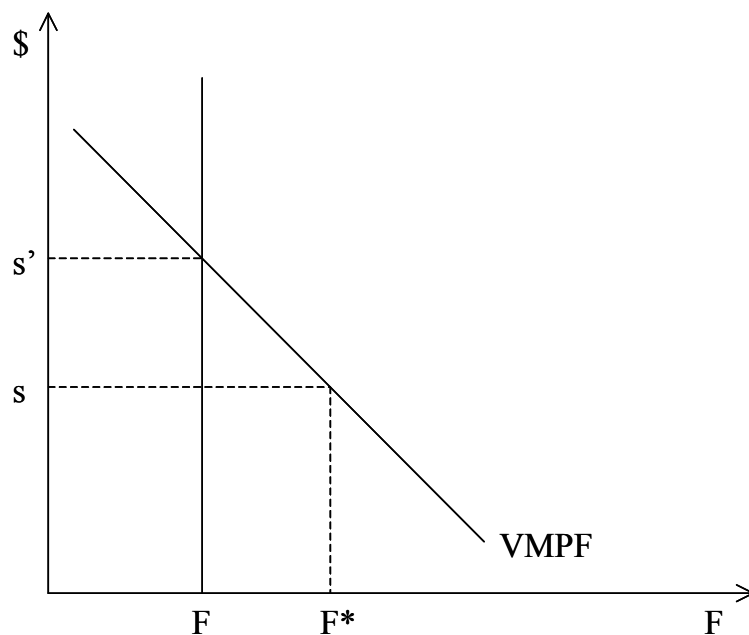


Figure 2.11. Effects of liquidity constraints on market inputs purchase

Access to credit releases the liquidity constraint and –under the fungibility of funds– allows the household to shift the perceived budget constraint back towards its initial position. Therefore, the more credit constrained the household is, the larger the distortion in factor proportions against market inputs and in favor of land. Credit rationing changes this proportions. Under the assumption that the expansion of agricultural land implies environmental degradation, households having access to credit will exert less pressures on land and, therefore, access will positively impact resource conservation.

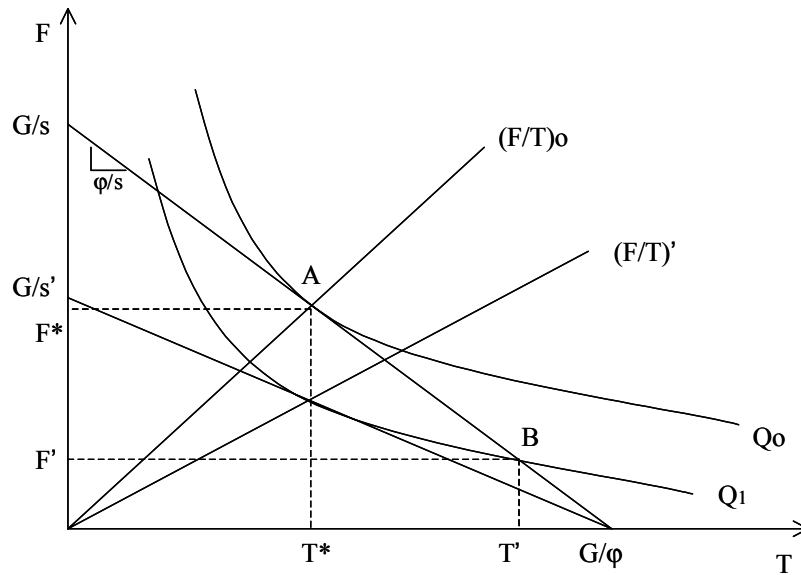


Figure 2.12. Effects of liquidity constraints on factor proportion decisions

Demand for microenterprise family labor

$$\alpha E \left(\frac{\partial V_{t+1}}{\partial b_{t+1}} \right) \left(\frac{\partial M}{\partial H m_t} - w_t \right) = 0 \quad (2.28)$$

Similar to the agricultural input conditions, this condition states that the household will allocate family labor to the microenterprise up to the point where the expected marginal revenue equals the expected marginal cost.

Demand for off-farm family labor

$$\alpha E \left(\frac{\partial V_{t+1}}{\partial b_{t+1}} \right) (w'_t - w_t) = 0 \quad (2.29)$$

Generally, these conditions imply that the household allocates labor among different activities to maximize the expected utility of profits from each activity. The amount of labor effort allocated to agriculture is obtained from the difference between the total available labor force and the sum of the allocations of labor to the microenterprise, off-farm activities, and leisure. If $Hq_t > L_t$, this household will be a net supplier of agricultural labor. If $Hq_t < L_t$, this household will be a net user of agricultural labor.

Investment

$$-\alpha E \left(\frac{\partial V_{t+1}}{\partial b_{t+1}} \right) + \alpha E \left(\frac{\partial V_{t+1}}{\partial K_{t+1}} \right) = 0 \quad (2.30)$$

This condition calls for equating the expected discounted benefits (costs) from sacrificing a unit of consumption in the current period and the benefits from converting this unit of investment into capital goods able to generate income and therefore increase consumption in the next period.

Updating the value function to period $t+1$, deriving with respect to k_{t+1} and b_{t+1} , and after manipulating these conditions and substituting into equation (2.23), it can be shown that on the optimal path the following condition will hold:

$$E \left[\frac{\partial V^{t+1}}{\partial b_{t+a}} \left\{ \frac{1}{1+r} \left(\delta + \frac{\partial M}{\partial K_{t+a}} \right) - 1 \right\} \right] = 0 \quad (2.31)$$

This condition implies that the household will maximize expected utility by comparing the marginal profit of capital in the microenterprise net of depreciation with

the present forgone consumption, so that the discounted net marginal benefits of investment go to zero.

Demand for funds

$$\frac{\partial V_t}{\partial B_t} = \alpha E \left(\frac{\partial V_{t+1}}{\partial b_{t+1}} \right) \leq 0, \quad B_t \geq 0, \quad \frac{\partial V_t}{\partial B_t} B_t = 0 \quad (2.32)$$

This condition states that the household will demand funds up to the point where the expected discounted net benefits of doing so go to zero. In a deterministic case, the sources of the demand for funds would be the intertemporal reallocation of consumption and the formation of capital to increase future income. The path for the use of credit would converge to a steady-state value where the depreciation of capital and the intertemporal allocation of consumption are the main components. Under uncertainty, however, the demand for funds becomes an important tool to smooth income and consumption over time, so that the household can remain as close as possible to the expected paths of consumption and income as time goes on. In this case, the path for the use of credit will fluctuate around the deterministic path in a trend that converges to a steady-state value.

It is important to recall, however, that the realization of the demand for funds (as well as the other decision variables) will be shaped by the credit-rationing condition. A household without credit constraints will equal the price of the loan, r_0 , to the value of the marginal product of using the funds in taking advantage of productive opportunities. In Figure 2.13 this would correspond to the loan size B^* .

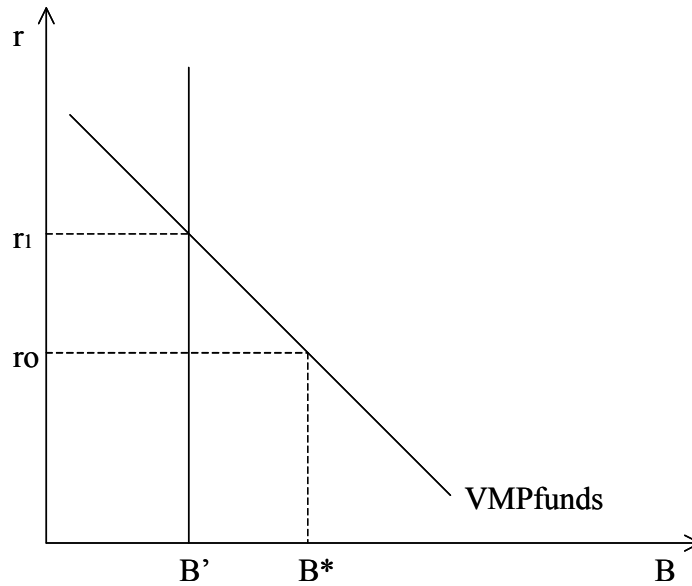


Figure 2.13. Effects of credit rationing on household decisions

There may be, however, quantity rationing, emerging from one or several of the behaviors discussed in the review of the literature. Under quantity rationing, the household is only granted the amount B' . In this case, the shadow price of the loan will be $r_1 > r_0$. Now the household is not able to equate the value of the marginal product of the resources purchased with the loan to its price, r_0 , but instead it equates it to the shadow price resulting from credit rationing $r_1 = r_0 + \beta$. The result is equivalent to the outcome of adding some transaction costs, β , to the price of the loan. A similar effect would be observed even if the household is subject to price rationing, but where actual transaction costs, β , are added to the price of the loan. There is, however, a difference. Under quantity rationing, the household is not able to decide on the loan size, while

under price rationing it can decide whether to engage in debt or not and for what amount, at the whole price r_t . In the first case, the household is missing gains from its productive opportunities, even if it is able to afford the full loan repayment, with transactions costs included.

2.6.2. Implications of the Model for the Empirical Analysis

All of the first-order conditions for the intertemporal optimization of the household's objective function, along with the corresponding equations for the evolution of the state and co-state variables and with the initial and final conditions, constitute a set of equations. Implicitly, this set of equations represents the structural form of a system of demand equations for consumption goods and for production inputs and of supply equations of labor effort and goods produced by the household over time. The solutions to this system of demand and supply functions will be determined simultaneously, and they will depend on exogenous variables as well as on the model's parameters.

Assuming that this structural system can be expressed as a set of reduced-form equations, there exists an optimal plan z_t that will be a function of the state variables at every period and of parameters involving prices, discount rates, interest rates, depreciation rates, and endowments, conditional on random shocks and on the credit rationing condition. This system of reduced-form equations shows that the household's decisions are made simultaneously for consumption and production and that separability cannot be warranted, given uncertainty:

$$z_t = z_t(b_t, K_t, p_t, r, e, \delta, H_t, A_t | \varepsilon; \theta) \quad (2.33)$$

The vector z_t implies that the set of equations, simultaneously determined, must have a solution. Assuming that all variables in the right-hand side of the solutions are exogenous, each equation can be estimated independently of each other and, therefore, it is possible to focus on the variables of interest. In particular, the decision about the amount of land for cultivation is the variable of interest in this dissertation.

As already discussed, I choose land for cultivation as a proxy for environmental degradation, under the assumption that households first use the plots (or portions of plots) with the highest productivity (in terms of soil fertility, slope, access to irrigation and the like) and with the least propensity for degradation. Then, when they make decisions about expanding and using marginal land, they contemplate the use of plots that are less and less productive and more and more fragile, as they will be subject to erosion and other environmental problems. This assumption responds to circumstances typically observed through the OSU field work in El Salvador.

The decision about the use of land for cultivation can be depicted in a reduced form as:

$$Aq_t = Aq_t(b_t, K_t, p_t, r, e, \delta, H_t, A_t | \varepsilon; \theta) \quad (2.34)$$

That is, the demand for land will be shaped by the determinants of consumption (that is, by the price of consumption goods, household endowments, preferences, and discount rates) and by the determinants of production (that is, by degrees of access to credit and interest rates, the rate of depreciation of capital goods, the availability of land, and –as a result– income and/or profits), conditional on random shocks and on the

characteristics of the household that make it quantity rationed or not. Given the binary nature of the credit rationing condition, the demand for land can be rewritten as:

$$Aq_t^R = Aq_t(b_t, K_t, p_t, r, e, \delta, H_t, A_t | \varepsilon) \quad \text{if } \theta = 1 \quad (2.35)$$

$$Aq_t^{NR} = Aq_t(b_t, K_t, p_t, r, e, \delta, H_t, A_t | \varepsilon) \quad \text{if } \theta = 0$$

where the super index R stands for a rationed household and NR stands for a non-rationed household. That is, decisions about use of land for cultivation (as well as other decision variables) can be expected to be different for households that are credit constrained (quantity-rationed) than for those that are not.

This basic framework is therefore useful to suggest many possible determinants of the decisions about land use that can be employed in the empirical analysis. This framework also justifies the consideration of two separate regressions to explain land use, depending on the quantity-rationed condition for every household.

From this model, five types of variables must be considered in the empirical estimation:

- *Use of external funds.* The simplest way to approach the use of external funds is to include in the regressions the size of the loans that the household has been granted. These loans may be either from formal sources, namely financial intermediaries whose main purpose is to offer financial services (private and public banks, credit unions and cooperatives, savings and loans associations, microfinance institutions, and other non-governmental and development lending agencies), or from informal sources, which include moneylenders, participants in

a number of interlinked transactions, and relatives and friends, as well as credit offered by suppliers and commercial firms and other marketing intermediaries.

- *Household capital.* There are various types of capital that a household may own, and at least two types are considered here. First, there is physical capital, which refers to the stock of physical assets that a particular household owns in a given period, such as farm equipment, other productive assets, and household durables. Second, there is human capital, which refers to the bundle of skills and abilities of the household members, which are available for income generation. The measurement of human capital is approached either by the number of years of education of the potential workers in the household or by the experience accumulated by these members.
- *Household endowments.* There are two types of endowments of relevance in this model, beyond the stock of capital already discussed. First, there is the labor endowment, which refers to the amount of the labor force available to the household for the generation of income. This endowment is usually measured by the number of potential workers in the household, as given by people above and below a certain age. Second, there is the land endowment, which accounts for the total available land that the household has, which can be used for agricultural purposes or, eventually, sold in order to generate liquidity.
- *Prices.* Market prices are difficult to incorporate in the empirical analysis, given the large diversity of consumption and production goods that are part of a typical bundle for the household. A price index can be used to capture the variability of

prices over time. However, given the characteristics of the longitudinal panel used in this dissertation, there would be low variability or none in these price indexes among households, for a given region and period. Instead, to approach market conditions, I decided to use income as a variable that captures these effects in a comprehensive fashion. There are two justifications for this decision. First, income generation and consumption decisions by the household depend on market prices. Therefore, controlling for changes in the use of inputs and considering a relatively stable path of consumption, changes in income may reflect the effects of market prices. Second, given that the purpose of this essay is to test for the existence of an environmental Kuznets curve, income is one variable that cannot be excluded from the analysis. Using price indexes or any other approach to prices simultaneously with income would lead to collinearity problems in the empirical estimation.

Besides this set of theoretically predicted variables, other variables that control for particular characteristics of the household (*e.g.*, type of farm, technology, and risk coping strategies) must be included in the empirical analysis.

2.6.3. Theoretical Development of the Precautionary Demand for Land

The dynamic model to be developed as a theoretical framework for this study will focus on an aspect of land clearing for agricultural purposes in places like El Salvador that is puzzling at first glance, and that has been identified by Rodríguez-Meza, Southgate and González-Vega (2004). These authors argue that with commodity prices

falling rapidly and crop yields being diminished by drought, storms, and earthquakes, it would be expected that farmed area would decline over time, especially if non-agricultural employment and opportunities for migration abroad have been increasing. However, precisely the opposite has been happening in El Salvador.

The key to explaining this anomaly is to appreciate that, along with purely commercial demands for agricultural land, there exists a demand for farmland that is best characterized as precautionary. That is, households –especially those that are below the poverty line– are interested in having land that can be used for subsistence farming in case of adverse shocks. This precautionary demand is a decreasing function of income. A poor family benefits from having a site to raise some of its own food even in relatively good times. In good times, however, an important fraction of the household’s labor supply is more profitably allocated outside the family’s farm. Only a portion of the household’s land holding –the least environmentally fragile portion– is therefore cultivated, mostly as an income diversification strategy.

The household’s precautionary demand for farmland is especially pronounced in relatively bad times. During these times, more labor is devoted to subsistence farming, and the cultivated portion of the household’s landholding increases. In contrast, this demand is negligible for an affluent household. Also, this type of household usually possesses assets and access to markets –a credit line, a savings account, goods that can be sold or pawned, family remittances– that can be used to maintain consumption in the face of an income shortfall.

Just as the precautionary demand for cultivable land varies from one economic agent to another, there are major differences among households' access to the sort of land that lends itself to farming. Besides the option of purchasing land for agricultural purposes, another option, in many parts of the developing world, is to occupy a tree-covered parcel that no one else claims and clear it to make way for crop production. Either action carries costs, costs that typically are easier for a non-poor household to bear than for an impoverished family.

Rodríguez-Meza, Southgate and González-Vega (2004) show that the relationship between income and agricultural land use is the net result of these two different influences. One of these influences relates to a household's precautionary demand for land. The other influence has to do with a household's wealth and purchasing power. For low levels of income, the first influence dominates, and many households are left with an unsatisfied willingness to cultivate more land. As their income increases, their command over resources increases and additional land is cultivated. For high levels of income, in contrast, the second influence dominates and the declining demand for cropland is binding.

As a result, a microeconomic EKC for agricultural land use is obtained, from a precautionary demand for land that can be better satisfied as income increases and, after a threshold, from an excess of ability to acquire land over this demand. At one extreme are the poorest of all rural dwellers –that is, people whose precautionary demand is sizable compared to their ability to gain access to land. Because the cost of access to cultivable land is prohibitive for these people, the area they use to grow subsistence

crops is quite limited; indeed, many of them are landless. At the other extreme is the least poor segment of the rural population, which has ready access to land. Among this group, though, the precautionary demand is negligible, which causes the household to refrain from farming a lot of land. Between the two extremes are households with two characteristics. First, their incomes are lower than the levels at which the precautionary demand for subsistence farmland becomes irrelevant. Second, they do not find the cost of access to such resources to be prohibitive. Accordingly, average land use is highest in this intermediate group.

Moreover, the limited income and consumption smoothing opportunities associated with this behavior reflect constraints on risk-management options in rural areas. The high costs or failure of risk-coping strategies typically reflect constraints on access by the poor to alternative, less-costly risk-management options that are available to wealthier households, mostly through their access to labor and financial markets.

Earlier observations of the OSU-FUSADES team suggest that, largely, non-poor rural households have been able to withstand environmental and market shocks (González-Vega and Beneke de Sanfeliú, 2000). Possessing sufficient human capital — the most important asset in this environment— as well as better access to markets and jobs, non-poor households have succeeded in diversifying their portfolios away from declining farming incomes. Indeed, increases in non-agricultural earnings —resulting in part from the expansion of *maquilas*— have more than compensated for whatever farming losses households above the poverty line have suffered. Accordingly, their incomes have steadily risen over the period of observation.

The rural poor, who earn much of their incomes as wage laborers on other people's farms, have suffered as agricultural employment has contracted with the shocks. Because of little education, high transactions costs resulting from an inadequate physical and institutional infrastructure, and policy-induced distortions that accentuate potential failure in land, labor and financial markets, rural households below the poverty line have found it difficult to compete for non-agricultural occupations. With little chance of encountering alternative employment, many of the rural poor have responded by further shifting to subsistence basic grains production.

2.7. Econometric Analysis

The purpose of this section is to propose an econometric model to evaluate the impact of access to credit on land use for cultivation. The model will be estimated using the available information for El Salvador. This model is used as a framework for the empirical test of the hypotheses. After that, the expected responses from the variables included in the exercise will be discussed. Finally, results from the regression analysis will be presented and discussed.

2.7.1. Panel Data Considerations

The main characteristic of the data set available for this essay is that it combines time series and cross sections. This is an advantage in terms of the amount of information available but, at the same time, it involves complex stochastic specifications. The literature on panel data has developed standard techniques and

considerations to be included when working with longitudinal data sets (Greene, 2000). As is the case of the data being analyzed here, panel data sets are more oriented toward cross-section analyses: they typically involve numerous observations (they are wide) for a few moments in time (they are short), where heterogeneity across units is an integral part of the analysis. The fundamental advantage of a panel data set is that it allows for greater flexibility in modeling differences in behavior across households.

The basic framework for this discussion is a regression model of the form

$$y_{it} = \alpha_i + \beta' X_{it} + \varepsilon_{it} \quad (2.36)$$

where X_{it} , is a matrix of size $[K * T]$ – K regressors and T periods of observation– not including the constant term. The individual effect is α_i , which is taken to be constant over time t and specific to the i th household. Two basic frameworks are used to generalize this model. The fixed-effects approach takes α_i to be a group-specific constant term in the regression model. The random-effects approach specifies that α_i is a group specific disturbance, similar to ε_{it} except that for each group; there is a single draw that enters the regression identically in each period. Which one to use depends on the assumptions made about the specific functional form and on empirical testing.

For instance, the fixed-effects model is a reasonable approach when one can be confident that the differences between units can be viewed as parametric shifts of the regression function. In other settings, it may be more appropriate to view individual specific constant terms as randomly distributed across cross-sectional units, where random effects would be preferred (Greene, 2000). Other considerations should be included. Institutional factors or characteristics of the data can argue for one or the other

approach. From a purely practical standpoint in a wide, longitudinal data set, the random-effects model has some intuitive appeal. There is no justification, however, for treating the individual effects as uncorrelated with the other regressors. This favors the fixed-effects model. Empirically, it is possible to test for orthogonality of the random effects and the regressors, which offers insights on which approach is a better choice (Hausman, 1978).

Other econometric considerations should be included once the empirical model used to test for the hypotheses is chosen.

2.7.2. Theoretical Considerations

The main hypotheses to be tested with the econometric analysis are that access to financial markets (in particular, credit) shifts the environmental Kuznets curve, not only (i) by lowering the threshold level of income beyond which increases in income reduce the use of land for cultivation and therefore the degradation of natural resources, but also (ii) by shrinking the whole Kuznets curve such that, at every level of income, land use and environmental degradation are less.

In order to include the distinction between credit rationed and non-rationed households in the analysis, several alternatives have been proposed (Freeman, Ehui and Jabbar, 1998; Jabbar, Ehui and von Kaufmann, 2002; Lyons, 2003). A popular approach is to acknowledge the differentiation between credit-constrained and non-constrained borrowers and use a switching regression model to correct for possible sample selection bias, due to unobservable characteristics of the households (Feder *et al.*, 1990; Fuglie

and Bosch, 1995; Freeman, Ehui and Jabbar, 1998). This technique has been used in different settings (Sadoulet, de Janvry and Benjamin, 1998; Key, Sadoulet and de Janvry, 2000; Vince and Geoghegan, 2004).

For the current application, the switching regression approach uses a probit model in the first stage, to determine the probability of a household being credit constrained and to establish the relationship of this status with socioeconomic and loan terms variables. In the second stage, separate regression equations are used to model land use decisions by different categories of households, conditional on a specified criterion function.

Following Freeman, Ehui and Jabbar (1998), the credit-constrained condition of a particular household is described by an unobservable excess demand for credit, which is postulated to be a function of household socioeconomic, income generation, and credit terms-and condition variables. That is,

$$I^* = \delta'Z_{it} + u_{it} \quad (2.37)$$

The excess demand for credit is not observed but, using the available data, it is possible to identify those households whose productive activities are constrained by credit or not. According to the approach selected for this dissertation, the households are classified as subject to different types of quantity-constraining or not. To make access to credit a dichotomous variable, however, additional grouping of the households in the categories already defined is necessary. Therefore, for the purposes of this approach, two categories are proposed:

1. *Non-credit rationed or price-rationed households.* This group includes both types of price-rationed households, with and without a loan, and partially-rationed households that obtained at least 80 percent of the amount they requested.
2. *Credit-rationed or quantity-rationed.* This group includes risk-rationed and self-rationed households as well as fully and partially (households that obtained less than 80 percent of the amount requested) rationed households.

Next, I define a dichotomous variable, which takes the value of one if the household is credit rationed and zero otherwise. That is,

$$\begin{aligned}
 I &= 1 && \text{if } I^* = \delta'Z_{it} + u_{it} > 0 \\
 I &= 0 && \text{otherwise}
 \end{aligned}
 \tag{2.38}$$

The land use decision of the two groups of households is modeled by using separate regressions for each group.

$$\begin{aligned}
 Y_{1it} &= \beta_1'X_{1it} + u_{1it} && \text{if } I=1 \\
 Y_{2it} &= \beta_2'X_{2it} + u_{2it} && \text{if } I=0
 \end{aligned}
 \tag{2.39}$$

Estimating these models using OLS would yield inconsistent estimates of the coefficients, because the expected value of the error term conditional on the sample selection criterion is non-zero (Maddala, 1983). Therefore, following Lee (1978), a two-stage method is used to estimate this system of equations. From the first stage, an inverse Mills ratio can be obtained for each constrained or non-constrained household.

$$\lambda_{1it} = \phi(\delta'Z_{it})/\Phi(\delta'Z_{it})$$

$$\lambda_{2it} = \phi(\delta'Z_{it})/[1-\Phi(\delta'Z_{it})] \quad (2.40)$$

These terms are included in the specification of the second-stage equations, making their new residuals exhibit zero conditional means.

$$Y_{1it} = \beta_1'X_{1it} + \sigma_{1u} \lambda_{it} + \varepsilon_{1it} \quad \text{if } I=1$$

$$Y_{2it} = \beta_2'X_{2it} + \sigma_{2u} \lambda_{2it} + \varepsilon_{2it} \quad \text{if } I=0 \quad (2.41)$$

In order to account for possible heterogeneity within and between households through the longitudinal sample, a random-effects approach is included in the two-stage estimations.

The first stage uses a *random-effects probit regression* of the rationing condition on household socioeconomic variables, income generating activities, and use of financial services. The former include demographic characteristics, such as the age of the household's head and variables capturing household endowments, such as the total area of available land, an index of home assets, and the value of livestock owned. Distance to markets is included to reflect integration to markets. Income generating opportunities are captured by the number of microenterprises. Access to financial services other than credit is reflected by a dummy variable for households using bank deposits.

In stage two, separate regression equations are used to model agricultural land use decisions by the households, conditional on a specified criterion function for credit rationing. Here, the dependent variable is the area of land devoted to crops. Explanatory variables, along with income net of remittances and subsidies, also include demographic variables, income diversification options, agricultural related decisions, and control

variables. Demographic variables include both household size and the average level of schooling obtained by potential workers in the household. Income generation possibilities are captured by the shares of the household's labor force devoted to off-farm employment and to microenterprise activities and by the presence of remittances.

Agriculture-related variables include (i) a dummy for access to technical assistance (to capture the level of the technology used by the household), (ii) total expenditures in agricultural inputs per hectare (fertilizer, chemicals, seed, irrigation), in order to capture levels of intensification, (iii) the number of crops grown in order to capture diversification within agriculture, and (iv) an index reflecting the slope of the parcels, to capture plot-related characteristics. Total available land is used as a control variable. Home assets and the value of livestock are included to reflect other endowments that shape the household's decisions. Finally, loan amounts for the corresponding year are also included for both formal and informal sources, in order to capture potential substitutability or complementarity among sources of credit (Boucher, 2002; Rodríguez-Meza, 2002).

2.7.2. Empirical Estimation

In this section, I define the variables used in the empirical analysis, on the basis of the theoretical considerations above.

The use of external funds can be approached by using the size of the loans that households received from either formal or informal sources. Access to formal credit, as an income smoothing strategy, is expected to allow households to take advantage of

more rewarding productive opportunities, either agricultural –such as intensification– or non-agricultural –such as microenterprises, thereby reducing the pressures on land. However, formal loans can also finance extensification, thereby increasing pressures on land. When households are credit constrained, the null hypothesis is that there is an inverse relationship between the use of formal credit and land use. The theoretical prediction, nevertheless, is still ambiguous. Access to informal credit, in contrast, plays the role of a consumption smoothing strategy, as an alternative to use of land for this purpose. In this case, the relationship between the use of informal credit and land use is unambiguously expected to be inverse.

Variables related to the endowment of capital relate to both physical and human capital. An estimation of the value of assets owned by a household is a proxy for wealth. Household wealth is associated with more attractive income-generating alternatives. Pressures on land will be fewer in this case. Therefore, the hypothesis is that assets and land use are negatively related.

The human capital endowment is reflected by the levels of schooling of the members of the household. More education enhances labor productivity through increased managerial talent, broader access to information and markets, and the adoption of modern farming techniques (Godoy *et al.*, 1997; Tao Yang, 1997). Furthermore, higher levels of education imply a higher opportunity cost of on-farm labor, due to the increased wage earnings potential of household members in non-agricultural sectors. These opportunities reduce pressures on land (Vince and Geoghegan, 2004). Therefore, a negative effect of education on the area of land cultivated is expected.

The labor force endowment can be obtained by calculating, for each household, the number of members that are able to work. For this case, all members of the family 12 years old or older are considered to be potential workers. This variable reflects, at the same time, the household's supply of labor and consumption demand. This is the result of the non-separability in production and consumption as a consequence of the household's endogenous valuation of its time endowment (Vince and Geoghegan, 2004). A positive relationship between the labor force endowment and land use for cultivation is expected, in part due to the existence of thin labor markets.

The total land endowment is measured using the total available land of the household, and it is expected to have a positive effect on area cultivated since, *ceteris paribus*, greater access to land promotes more extensive farming practices. Furthermore, given imperfections in land markets, larger holdings offer more room to expand cultivation in order to smooth consumption without the high transaction costs of looking for land in the market.

Other control variables are included. First, variables reflecting the nature of the agricultural technology at the farm level should be contemplated. These variables must reflect access of and use by the household of intensification technologies (use of fertilizer, chemicals, improved seed, and irrigation). I have detailed information about the use of these agricultural inputs and their costs. Given that most of them are highly correlated, in order to avoid collinearity I aggregate the costs incurred by every household in purchasing all of these agricultural inputs. To avoid farm size effects, total costs in using modern inputs are divided by the area cultivated, to obtain average costs

of inputs. It is expected that the higher these costs, the higher the level of technology applied and so the intensification in the crop. Therefore, a negative relationship between land use and average cost of inputs is expected.

Another variable that reflects technological improvements in the household's plot is access to agricultural technical assistance. A dummy variable taking the value of one for those households using technical assistance and the value of zero for those that do not use this assistance is included in the model. Similarly to the case of the average cost of inputs, the expected sign is negative.

Ecological conditions (soil quality, slope, and access to irrigation) should be controlled for individual differences among farms. An index for the inclination (slope) of the terrain is included. This index is highly correlated with other ecological variables such as soil quality and access to irrigation; thus, including these other variables would incorporate collinearity without the gain of additional insights about household decisions.

In this dissertation, I argue that one possible reason for changes in the use of land for cultivation is the presence of shocks that affect the stability of the income paths of the household. In order to face these shocks, households engage in several coping strategies, which may be substitutes or complements to the alternative of increasing land use for cultivation. Ignoring these variables may bias the results or overlook important insights about how households make decisions about land use for cultivation.

Although there is an ample range of strategies that households can use for income smoothing, four are of particular importance and are considered in this analysis. One

strategy is to offer labor off the farm, either for agricultural or non-agricultural activities. By doing this, the household is trading off labor devoted to agricultural on-farm activities and, so, the expected sign of this coefficient is negative. Increasing off-farm opportunities should reduce pressure on the household's own land.

A second strategy for the household is to engage in non-agricultural activities within the household itself –mainly microenterprises. Similar to off-farm activities, a microenterprise reduces the availability of the household's labor force for agricultural activities, reducing pressure on land. The expected relationship between land for cultivation and microenterprise activity is negative. These two variables depend heavily on family size. To avoid a possible bias from family size, the variables are considered as the proportion of the potential labor force that is devoted to off-farm or microenterprise activities, respectively.

Households in El Salvador, in particular, and increasingly in other countries in Latin America, depend heavily on remittances as a source of income, particularly as a strategy to cope with risk, as shown by Pleitez-Chávez (2004). This variable is included in the regressions to investigate the impact that remittances have on land use decisions. The expected impact is, however, ambiguous. On the one hand, households may use these transfers for agricultural intensification or microenterprises, thereby reducing pressure on land. On the other hand, households may be interested in acquiring more land for savings purposes and future income generation, thereby increasing pressure on land. Moreover, remittances are also part of the household's risk-coping alternatives and

would tend to reduce pressures on land. Nevertheless, the theoretical sign of the coefficient remains undetermined and the direction of impact is an empirical issue.

Households facing environments with high variability of yields and prices may adopt crop diversification as a strategy to reduce the resulting risk. This is a costly strategy, because it will limit the household's opportunities for specialization and use of its comparative advantages. Households engaging in crop diversification would increase pressure on land, with a negative impact on natural resource conservation. Thus, a positive relationship between diversification and land use is expected.

Finally, the variable used to test for the presence of an environmental Kuznets curve is household income per capita. Income here is measured as the flow of revenues from the different productive activities of the household –including both on-farm and off-farm earnings– net of the costs incurred in productive activities (agricultural and microenterprise inputs) and net of transfers –including remittances–. The calculation of household income for the panel was undertaken by researchers within the Rural Finance Program at OSU, and, in particular, by Jorge Rodríguez-Meza.

This essay builds on findings by Rodríguez-Meza, Southgate and González-Vega (2004) who, using the complete four-survey panel for El Salvador, estimate a Kuznets curve between per capita income and the area of cultivated land at the household level. These authors argue that this curve should be obtained from a measure of permanent income rather than the total income actually observed in each period.

Given that permanent income is not directly observable, these authors estimate predicted income by regressing observed current income per capita net of remittances

and subsidies against a set of explanatory variables. These variables include the human capital of the household's active labor force, an index of home assets, distance to the nearest paved road, number of microenterprises operated by the household, number of members of the household who are employed off the farm, the value of the stock of animals at the end of the year, the number of members of the household that participate in agricultural activities at the farm, an index of overcrowding in the house, and a dummy for the use of agricultural technical assistance services. I follow this approach and calculate, in a separate regression, the predicted income per capita to be used in the subsequent estimations.

Statistics for the dependent and independent variables used in these models are presented in Tables 2.13 and 2.14. Table 2.13 shows statistics about the sample of households that participated in the 1999 and 2001 surveys and that are used in the estimation of the credit rationing condition (first stage). Table 2.14 filters this sample to include only those households that held land during either one of these two years and that are used in the estimation of the land use decision (second stage).

The dependent variable for the estimation of the environmental Kuznets curve is the number of hectares of land devoted to crop cultivation during the period analyzed. Although the survey includes farmers and non-farmers, for the purposes of this analysis, only those households that have some land devoted to agriculture are considered. Otherwise, the results will be biased, as households without cropland are not exerting any pressure on this resource.

Variable	Units	ALL		FARMERS		NON-FARMERS	
		Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.
Number of observations	Number	919		579		340	
Agricultural land used	Hectares	0.67	1.10	1.06	1.22	0	0
Permanent income	`000 colones	6.50	3.29	6.32	3.61	6.79	2.65
Total household income	`000 colones	6.49	7.21	6.26	7.56	6.90	6.59
Average household human capital	Years of education	3.79	2.83	3.69	2.76	3.96	2.95
Family size	Number	6.04	2.72	6.12	2.80	5.91	2.56
Total land holdings	Hectares	1.85	3.79	2.44	4.02	0.85	3.10
Assets	Index	9.21	10.93	9.55	11.51	8.61	9.85
Share of off-farm workers	Percentage	0.37	0.28	0.33	0.28	0.42	0.29
Share of workers in microenterprises	Percentage	0.13	0.25	0.13	0.24	0.12	0.26
Livestock	`000 colones	1.82	2.24	2.30	2.35	1.00	1.77
Remittances	`000 colones	5.32	12.57	5.59	13.83	4.87	10.07
Index of crop diversification	Number of crops	1.42	1.56	2.25	1.42	N/A	
Index of slope	1-4 index	2.98	0.86	2.98	0.86	N/A	
Use of technical assistance	Binary (1=use)	0.09	0.29	0.09	0.29	N/A	
Average input costs	`000 colones per hectare	1.00	5.55	1.00	5.55	N/A	
Formal loan size	`000 colones	1.43	7.46	1.42	7.84	1.45	6.77
Informal loan size	`000 colones	0.36	2.11	0.38	1.95	0.33	2.36
Household head age	Years	52.82	14.32	53.96	13.63	50.86	15.25
Use of deposit services	Binary (1=use)	0.27	0.44	0.25	0.43	0.31	0.46
Number of microenterprises	Number	0.38	0.65	0.35	0.64	0.43	0.68
Distance to markets	Minutes	39.97	34.30	43.38	36.08	34.12	30.20

Table 2.13. Descriptive statistics of variables used in the regressions for rationed and non-rationed households.

Variable	Units	NON RATIONED					
		ALL FARMERS		RATIONED		RATIONED	
		Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.
Number of observations	Number	575		243		332	
Agricultural land used	Hectares	1.06	1.23	1.31	1.40	0.88	1.05
Permanent income	`000 colones	5.79	3.73	6.54	4.10	5.24	3.34
Total household income	`000 colones	6.21	7.51	7.13	8.01	5.55	7.06
Average household human capital	Years of education	3.67	2.71	4.18	2.87	3.30	2.53
Family size	Number	6.13	2.80	6.15	2.87	6.12	2.76
Total land holdings	Hectares	2.44	4.03	3.30	5.01	1.82	2.97
Assets	Index	9.53	11.46	11.34	12.96	8.21	10.04
Share of off-farm workers	Percentage	0.33	0.28	0.31	0.28	0.35	0.27
Share of workers in microenterprises	Percentage	0.13	0.24	0.16	0.26	0.10	0.22
Livestock	`000 colones	2.31	2.35	2.42	2.51	2.23	2.22
Remittances	`000 colones	5.62	13.87	5.42	11.35	5.77	15.46
Index of crop diversification	Number of crops	2.25	1.42	2.41	1.61	2.14	1.26
Index of slope	1-4 index	2.98	0.86	2.98	0.87	2.97	0.85
Use of technical assistance	Binary (1=use)	0.10	0.30	0.15	0.36	0.06	0.24
Average input costs	`000 colones per hectare	2.38	8.41	2.98	12.63	1.94	2.38
Formal loan size	`000 colones	1.42	7.87	2.50	10.90	0.63	4.36
Informal loan size	`000 colones	0.38	1.95	0.53	2.64	0.27	1.22
Household head age	Years	54.05	13.62	53.84	12.84	54.20	14.19
Use of deposit services	Binary (1=use)	0.25	0.43	0.33	0.47	0.19	0.39
Number of microenterprises	Number	0.35	0.64	0.40	0.69	0.31	0.60
Distance to markets	Minutes	43.40	36.15	42.03	36.03	44.39	36.25

Table 2.14. Descriptive statistics of variables used in the regressions for rationed and non-rationed households cultivating land.

Except for holdings of land and livestock, Table 2.13 does not reflect dramatic differences in the average values of the independent variables for farmers (who cultivated land) and non-farmers. One exception is the larger share of off-farm workers in the labor force of non-farming households. In contrast, Table 2.14 shows major differences between credit-rationed farming households and those not rationed. Non-rationed households hold and cultivate larger areas of land, earn higher incomes by deploying larger stocks of human capital, and possess more assets. The number of microenterprises and the proportion of the labor force that they employ are larger for non-rationed households. In cultivating their land, they purchase larger amounts of market inputs and use technical assistance more frequently. They hold financial deposits more frequently and get larger loans. These differences may reflect either demand or supply of credit factors, which is addressed next.

Results for permanent per capita income estimations are presented in Table 2.15. The regressions use information from all of the four years when the survey was undertaken. This is an advantage of the panel, which makes it possible to calculate permanent income for every household present in the sample for the whole period of analysis. The results obtained here resemble those from Rodríguez-Meza, Southgate and González-Vega (2004). The differences are due to the fact that I use a random-effects model instead of the fixed-effects model used by these authors. The signs of the coefficients and their significance continue, however, to be the same.

Variable	Coefficient
Human capital	.233 ***
Asset index	.163 ***
Distance to markets	-.006
Workers in microenterprise	.832 ***
Workers off farm	.308 ***
Value of livestock	.000 ***
Workers at the farm	-.403 ***
Crowding	-.388 ***
Technical assistance	.512
Year 1997	-.004
Year 1999	1.681 ***
Year 2001	2.001 ***
Constant	3.536 ***
Rho	.090
R2 within	0.094
R2 between	0.509
R2 overall	0.283
Observations	1881
Groups	492
Wald chi2(k)	619.27

*** significant at 1% ** significant at 5% * significant at 10%

Table 2.15. Estimation of permanent income using random effects

Once the equation for permanent income is estimated, the next step is to evaluate the equation for land use for cultivation as a function of income and the variables mentioned above, for 1999 and 2001. A first approach is to run this regression using the

pooled data set and assuming that there are no differences between rationed and non-rationed households. Results from this estimation are presented in Table 2.16.

Variable	Coefficient	Elasticity	Average
Income	.042**	.183**	5.228
Income squared	-.001**	-.032**	77.077
Household human capital	.007	.020	3.541
Family size	.047***	.240***	6.161
Land holdings	.127***	.288***	2.723
Assets index	.001	.004	8.525
Share of off-farm workers	-.402***	-.096***	.285
Share of workers in microenterprises	-.200	-.017	.099
Livestock value	-.001	-.001	2.313
Remittances	-.002	-.006	4.364
Index of crop diversification	.216***	.395***	2.194
Plot slope index	.107***	.254***	2.842
Use of technical assistance	.026	.003	.131
Average inputs cost	-.014**	-.026**	2.189
Formal loan size	.021***	.028***	1.610
Informal loan size	.008	.003	.475
Year 2001	-.318***	-.076***	.286
Constant	-.196		
Rho	0.072		
R2 within	0.129		
R2 between	0.457		
R2 overall	0.359		
Observations	1008		
Groups	378		
Wald chi2(k)	495.42		
Breusch and Pagan Test	115.97***		
Hausman test	161.92***		

*** significant at 1% ** significant at 5% * significant at 10%

Table 2.16. Estimation of agricultural land use using random effects without discriminating between rationed and non-rationed households.

Results from this regression show two relevant consequences of using this approach. First, for the pooled sample there is statistical evidence of an EKC. Second, the use of formal credit seems to have a significant and positive effect on the area of land cultivated. These results would suggest that increasing access to credit will lead to further pressures on land. However, as already mentioned, there is a specification problem here. Among those households using credit, some of them may have been rationed and have obtained only a partial amount compared to their full demand. At the same time, among those households without any use of credit (zero loan size), some of them may have actually applied for a loan and have been rejected, while some may have decided not to apply, because of the fear of losing their collateral, of high transaction costs or the high cost of the non-interest components of the price vector of the loan, or may have self-selected out of the credit market. Some others may not need credit, either because they are able to self-finance or do not have productive opportunities with which to make a loan an attractive option. It is a common weakness not to differentiate among those groups, and therefore the results from an aggregate regression may not lead to the correct interpretation.

In order to gain more insights from the available information, an option is to split the sample into two groups: quantity-rationed households and non-quantity rationed households, classified according to methodology proposed in this essay. It then becomes possible to run separate regressions for each group. Results from these regressions are presented in Table 2.17.

Variable	Credit constrained			Credit non-constrained		
	Coeff	Elasticity	Average	Coeff	Elasticity	Average
Income	.074*	.485*	5.752	.102	.560	7.073
Income squared	-.001	-.071	43.296	-.006*	-.292*	65.412
Household human capital	-.014	-.054	3.295	.012	.039	4.179
Family size	.037**	.258**	6.112	.023	.108	6.148
Land holdings	.115***	.238***	1.820	.112***	.288***	3.301
Assets index	-.010	-.093	8.210	.020*	.173*	11.335
Share of off-farm workers	-.210	-.085	.353	-.377	-.090	.309
Share of workers in microenterprise	-.205	-.024	.104	-.463	-.057	.159
Livestock value	-.014	-.035	2.227	-.004	-.008	2.420
Remittances	.003	.020	5.788	-.007	-.031	5.421
Index of crop diversification	.179***	.436***	2.136	.143***	.267***	2.407
Plot slope index	.043	.146	2.980	.155*	.359*	2.977
Use of technical assistance	.140	.010	.060	.083	.010	.148
Average inputs cost	-.039***	-.086***	1.947	-.009	-.020	2.982
Formal loan size	.112***	.081***	.633	-.006	-.011	2.504
Informal loan size	-.008	-.003	.273	-.032	-.013	.529
Year 2001	-.138**	-.083**	.523	-.319**	-.117**	.473
Constant	-.124			-.211		
Rho	.287			.299		
R2 within	0.272			0.089		
R2 between	0.731			0.356		
R2 overall	0.646			0.323		
Observations	331			243		
Groups	236			177		
Wald chi2(k)	563.29			95.75		
Breusch and Pagan Test	15.35***			8.20***		
Hausman test	31.98**			69.75***		

*** significant at 1% ** significant at 5% * significant at 10%

Table 2.17. Estimation of agricultural land use for rationed and non-rationed households using random effects, without correction.

The sample, for the two years of analysis, is made up of 574 households that use land for cultivation. From these households, 331 of them (58 percent) are credit rationed and 243 (42 percent) are not-credit rationed households.

These results show that the signs for the income variable, which hypothesize the existence of an environmental Kuznets curve, are as expected, although only one of the coefficients is statistically significant in each case. The coefficient for income is not significant for non-constrained households, which suggests that they have sufficient purchasing power to satisfy their demand for land, while the coefficient for the square of income is not significant for rationed households. The latter result suggests that extra income relaxes the purchasing power constraint for credit-rationed households in ways that allow extra purchases of land.

Similarly, loan size also exhibits a different effect for each group. Credit-rationed households use their access to formal credit to increase the scale of their agricultural activity, as one would expect because of their excess demand for loans, and therefore increase the area of land cultivated. Indeed, credit-rationed households, by definition, have a high marginal productivity value from the use of credit in expanding the scale of their activities (including cultivation), in reflection of still unexploited opportunities as their liquidity constraint is binding without equality. This effect is statistically significant. Non-credit rationed households, in contrast, exhibit the opposite sign for the coefficient for loan size. This suggests that, once the marginal productivity value in agriculture is low enough, increases in access to credit reduce the impact of credit on the use of agricultural land. This coefficient, however, is not significant.

These results, nevertheless, have a drawback. The error term from the underlying equation that allows the separation into the two groups is assumed to be correlated with the errors in these two regressions and, therefore, estimating the regressions without considering this correlation would lead to biased and inconsistent estimates of the coefficients. Another way of stating the problem is to recognize that the credit-rationing condition may depend on unobservable variables that affect both the probability of being credit-rationed as well as the area allocated to cultivation and, therefore, land use and credit rationing may exhibit some endogeneity. A technique that addresses this threat must be adopted to avoid simultaneity bias and therefore a bias in the coefficient estimates (Vince and Geoghegan, 2004).

Switching regression models, as explained above, are used to correct for possible selection bias, which may arise from other characteristics that define a household's classification in addition to credit (Lapar, 1994). This technique implies two stages. The first stage consists of running a probit regression (in this case with random effects) to estimate the probability that a given household is rationed as a function of a set of variables (socioeconomic and credit-related) that affect the likelihood of being rationed. Results from the first stage can be observed in Table 2.18. The table shows that credit rationing, as defined here, is a response to both demand-side and supply-side circumstances, which result in households having full access to credit or not.

The variables used in this regression are intended to reflect the characteristics that a household possesses, either demographic or reflecting integration into markets,

that eventually can be used by lenders for screening purposes (available liquidity and collateralizable assets).

The age of the household head measures some dimensions of human capital (experience). Including age in both lineal and squared forms, I assume that there is a given age of the head at which the household, *ceteris paribus*, reaches a maximum probability of being non-rationed. The logic is that young household heads will exhibit high labor productivity and willingness to adopt modern farm technologies but that they lack experience. At the other extreme, older household heads have accumulated experience and reputation, but their willingness to adopt new technologies and their managerial talent are limited. In the middle, households exhibit a combination of both experience and talent that leads to the lowest level of rationing. Therefore, the hypothesis is that the relationship between the probability of being rationed and age exhibits a U-shaped parabola, and thus the sign of the lineal coefficient is negative and the sign of the squared coefficient is positive. This hypothesis is partially confirmed in the estimation through the sign and significance of the squared term.

Integration to markets is measured in three ways. First, distance to markets, measured in minutes of travel, shows how far the farm is from markets. The assumption is that markets are economic centers where households engage in trade and, possibly, where the branches of financial institutions are located. It is expected that the farther the farm is from the market place, the higher the transaction costs of travel and therefore the greater the probability of not being integrated to markets. The hypothesis is that the sign

of the coefficient for distance to markets is directly related to the probability of being rationed. The actual results for this variable are inconclusive due to lack of significance.

Variable	Coefficient	Semi elasticity			
		At mean	At median	Mean	Median
Household head's age	-0.045	-2.365	-2.325	52.9	52
Household head's age squared	0.000*	1.357*	1.222*	3,004	2,704
Bank deposits	-0.475***	-0.131***	N/A	0.275	0
Microenterprises	-0.092	-0.035	N/A	0.383	0
Assets index	-0.008	-0.075	-0.048	9.268	6
Land holdings	-0.084***	-0.154***	-0.058***	1.831	0.694
Livestock value	-0.015	-0.028	-0.015	1.825	1
Distance to markets	0.001	0.044	0.033	39.968	30
Year 2001	0.087	0.042	N/A	0.482	0
Constant	1.780**				
Rho	0.468				
Observations	885				
Groups	468				
Wald chi2(9)	42.750				
Log likelihood	-536.98				

*** significant at 1% ** significant at 5% * significant at 10%

Table 2.18. Estimation of the rationing condition using a random-effects probit.

Second, the use of deposit services reflects that households are more integrated to the modern financial sector and, therefore, this may indicate a lower propensity to be credit rationed. Among other things, deposits generate information for potential lenders

that assists in screening and facilitate the accumulation of a downpayment. This assumption leads to the hypothesis that the probability of being credit rationed and the use of financial deposit services are inversely correlated. This hypothesis is confirmed by the regression.

Third, the number of microenterprises is included by assuming that households better integrated into markets have more possibilities of engaging in non-agricultural activities. The hypothesis is that the greater the number of enterprises, the less the probability of being credit-rationed. Although the resulting coefficient has the expected sign, the statistical significance is low.

Variables reflecting the availability of potentially collateralizable assets and, therefore, less of a propensity to be credit-rationed are ownership of movable assets, livestock herds, and the area of total land. These variables are easily observed by lenders, and therefore are frequently used in the applicant screening process. The expected sign for the coefficients of these variables is negative. The signs are confirmed from the regression results, but only the coefficient for land holdings is statistically significant. In the case of movable assets, the variable accounting for these assets does not discriminate among types of assets; some of them are productive, while others are not. Given weaknesses in the legal structure and judicial practice, movable goods are usually not acceptable as collateral, except by a few microfinance lenders that have developed innovations in lending technologies to allow for this. The value of livestock variable includes not only large animals but also minor species (such as chickens, pigs, goats, and sheep), while it is mostly beef cattle that is acceptable as collateral. The value,

however, is highly correlated with the possession of large animals and thus it is a good proxy for the presence of beef or dairy cattle.

The error term from this equation is assumed to be correlated with the errors from the two equations explaining land use (for credit rationed and non-credit rationed producers) and all three terms are assumed to have a trivariate normal distribution.

In the second stage, separate equations are used to model the land use decision of groups of households (rationed and non-rationed) conditional on a specified criterion function. From the errors obtained in the first-stage equation, an inverse Mills ratio, defined by the ratio of the density function of the standard normal distribution to its cumulative density function, is calculated for each household. When appended as an extra regressor in the second-stage estimation, this ratio is a control for potential biases arising from sample selectivity (Vince and Geoghegan, 2004).

Coefficient estimates from the second-stage switching regression models for cropland are shown in Tables 2.19 and 2.20. Comparison of the average columns shows differences between the two categories. In general, non-credit constrained households exhibit higher incomes, more educated heads of household, larger land holdings, engage more frequently in microenterprise activities, spend more in agricultural inputs, use agricultural technical assistance more frequently, and use larger amounts of credit, from both formal and informal sources.

Variable	Coefficient	Elasticity at mean	Mean	Elasticity at median	Median
Income	0.082**	0.559**	5.748	0.623**	5.274
Income squared	-0.002	-0.097	43.073	-0.076	27.813
Household human capital	-0.016	-0.065	3.297	-0.071	3.000
Family size	0.033**	0.238**	6.062	0.286**	6.000
Land holdings	0.101***	0.211***	1.761	0.134***	0.922
Assets index	-0.010	-0.093	8.153	-0.055	4.000
Share of off-farm workers	-0.161	-0.068	0.355	-0.077	0.333
Share of workers in microenterprises	-0.153	-0.019	0.104	N/A	0.000
Livestock value	-0.012	-0.032	2.232	-0.035	2.000
Remittances	0.003	0.023	5.742	N/A	0.000
Index of crop diversification	0.196***	0.499***	2.146	0.565***	2.000
Plot slope index	0.069*	0.245	2.987	0.298	3.000
Use of technical assistance	0.098	0.007	0.062	N/A	0.000
Average inputs cost	-0.111***	-0.243***	1.852	-0.234***	1.469
Formal loan size	0.059**	0.029**	0.414	N/A	0.000
Informal loan size	0.008	0.003	0.279	N/A	0.000
Year 2001	-0.158**	-0.097**	0.517	-0.227***	1.000
Lambda	0.260	0.130	0.422	0.150	0.401
Constant	-0.194				
Rho	0.295				
R2 within	0.310				
R2 between	0.424				
R2 overall	0.428				
Observations	323				
Groups	232				
Wald chi2(k)	211.21				
Breusch and Pagan Test	20.36***				
Hausman Test	15.09				

*** significant at 1% ** significant at 5% * significant at 10%

Table 2.19. Estimation of a random-effects model for agricultural land use conditional upon the credit rationing condition for credit rationed households.

Variable	Coefficient	Elasticity at mean	Mean	Elasticity at median	Median
Income	0.141**	0.790**	7.137	0.662**	6.302
Income squared	-0.011***	-0.586***	66.019	-0.334***	39.719
Household human capital	0.000	0.001	4.274	0.001	4.000
Family size	0.030	0.145	6.091	0.136	6.000
Land holdings	0.065***	0.168**	3.287	0.071**	1.461
Assets index	0.012	0.113	11.600	0.069	7.500
Share of off-farm workers	-0.276	-0.067	0.311	-0.059	0.286
Share of workers in microenterprises	-0.372	-0.047	0.162	(no effect)	0.000
Livestock value	0.005	0.010	2.424	0.008	2.000
Remittances	-0.006	-0.029	5.668	(no effect)	0.000
Index of crop diversification	0.130***	0.247***	2.424	0.194***	2.000
Plot slope index	0.083	0.195	2.985	0.186	3.000
Use of technical assistance	0.117	0.014	0.147	(no effect)	0.000
Average inputs cost	-0.006	-0.014	3.024	-0.007	1.621
Formal loan size	-0.009	-0.019	2.533	(no effect)	0.000
Informal loan size	-0.024	-0.010	0.554	(no effect)	0.000
Year 2001	-0.305**	-0.111 **	0.463	(no effect)	0.000
Lambda	-3.322***	-3.174 ***	1.216	-3.128***	1.262
Constant	4.293***				
Rho	0.557				
R2 within	0.477				
R2 between	0.305				
R2 overall	0.313				
Observations	231				
Groups	170				
Wald chi2(k)	113.73				
Breusch and Pagan Test	8.67***				
Hausman Test	98***				

Table 2.20. Estimation of a random-effects model for agricultural land use conditional upon the credit rationing condition for non-credit rationed households.

The coefficients for the income variables (lineal and squared) confirm the hypothesis about the existence of an environmental Kuznets curve for each group of households. They are more statistically significant for the group of credit-rationed households, as one would expect, but in both cases, they exhibit a positive sign for the lineal coefficient and a negative sign for the squared income coefficient. These results suggest that the reduction in the marginal impact of income on area cultivated (squared variable) does not show up easily for credit-rationed households. In general, both additional income or access to credit push the budget constraint outwards. The more binding the credit constraint has been, the more likely additional purchasing power will be used to acquire land.

In effect, plotting the two curves, *ceteris paribus*, and evaluating all the other variables at their average values, the main hypothesis of this essay is confirmed: households being subject to credit constraints exhibit an environmental Kuznets curve where the threshold (the income level at which additional income levels start to be beneficial for the environment, because the area of cultivated land declines) is located at a higher income level than for households that are non-credit constrained. That is, households with greater access to credit will face a broader spectrum of possibilities to generate income and cope with risk and, as a consequence, they do not have to allocate labor to the cultivation of marginal land, with the implicit environmental degradation. This finding can be observed in Figure 2.14.

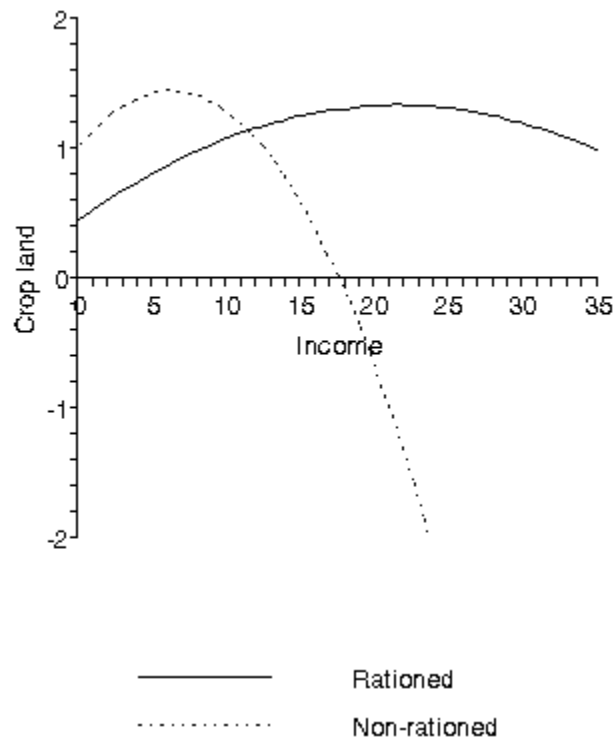


Figure 2.14. Plot of income versus agricultural land use for credit rationed and non-credit rationed households

This result is relevant for policymaking. Policies conducive to a reduction of the extent of credit-rationing of rural households will not only have beneficial effects on the households' opportunities for increasing income and overcoming poverty, but they also will reduce the threat of overuse of natural resources. In fact, for credit-rationed households, the threshold is located at 21,570 colones (US\$2,465) of income per capita, while for non-credit rationed households the threshold is located at only 6,239 colones (US\$713). These figures are relevant when considering that the median income per

capita for credit-rationed households is 5,522 colones (around one fourth of the threshold) while median income for non-credit rationed households is 6,560 colones (slightly higher than the threshold).

These findings imply that one-half of the non-credit constrained households already exert less and less pressure on land as a response to increases in income, while less than one percent among credit-constrained households, *ceteris paribus*, is behaving in this way.

These findings suggest that attempts to improve the lending technologies used by formal lenders would have a positive impact on natural resource conservation, through reductions in the area of cultivated land of less credit-constrained households.

Another interesting result from the regressions is that increases in access to credit, measured in terms of loan size, will lead non-rationed households to reduce their pressure on land for agricultural purposes. This may indicate that formal credit is used in these cases either for non-agricultural activities (microenterprises) or for the adoption of agricultural intensification technologies. Credit-rationed households behave in the opposite direction; given restrictions on their access to credit, increases in loan size will lead to increases in the use of land for cultivation, with the corresponding environmental pressure. The reason may be that, not having been able to obtain all the credit they demand, they would not have reached the optimum scale of cultivation, at the same time that they may have not been able to make the indivisible investments required for agricultural intensification or for the establishment of microenterprises.

The same effect is found for informal credit. The coefficients, however, are not statistically significant. This result suggests that informal credit may not be a strategy for income growth and smoothing, and that it is possibly used by households as a consumption smoothing alternative. In turn, the coefficient for the receipt of remittances also lacks significance, suggesting that remittances are not being used as an income growth and smoothing strategy but rather as a consumption-smoothing tool, which is consistent with the findings of Pleitez-Chávez (2004). In contrast, crop diversification is highly and positively correlated with land use for cultivation. Diversification and expanding the area cultivated are two strategies that act as complements in the set of income smoothing strategies. That is, to manage risk, households not only increase land for cultivation, but this increases are associated with a greater diversity of crops.

The number of members in the household is positively related to land use for cultivation, suggesting that labor markets are thin and that therefore the decision on increasing the allocation of land for agricultural purposes depends on the availability of a family labor force, especially for credit-rationed households. At the same time, this result suggests that the marginal allocation of land for cultivation responds mostly to the precautionary demand described by Rodríguez-Mesa, Southgate and González-Vega (2004), where allocating part of the household labor force to subsistence production is part of a self-insuring strategy. Under the threat of shocks, households decide to increase the cultivation of subsistence crops in order to improve their food safety net.

Other variables, such as the allocation of labor to off-farm activities or to microenterprises, reduce the pressures on land, although these coefficients are not

statistically significant. The use of agricultural technical assistance does not significantly affect marginal land use, while expenditures in agricultural inputs (as a proxy for technological levels) do reduce the allocation of land for cultivation at the margin, as expected. The control for the total land endowment exhibits the expected positive relationship. In fact, households with more available land are more likely to use it to manage risk and anticipate shocks.

In general, both equations show adequate goodness of fit. The Hausman test for the credit-rationed group indicates that there is no significant difference between a fixed-effects and a random-effects estimation. For the non-rationed group equation, a random effects model is preferred, according to the Hausman test. The switching model seems to be appropriate. The inverse Mills ratio coefficient is statistically significant in the equation for non-rationed households. Comparing the results with the pooled equation, and with the estimations without correction, it is possible to observe that there are gains from adopting the switching model, as the coefficients become unbiased and more information is obtained from the regressions.

2.7.3. Testing for the Robustness of the Credit Rationing Classification

A classification of households according to their access to credit was proposed in section 2.3. The main contribution of this approach was to consider those households that are rationed by transaction costs as being price rationed instead of quantity rationed. In contrast to Boucher (2002), I consider transaction costs as part of the price vector of the loan, as in González-Vega (1984). The two approaches generate different sub-

samples for the econometric analysis and, presumably, different results. To observe how sensitive the results are to this alternative classification, I undertake the econometric analysis again while assuming that transaction costs make households quantity rationed.

When compared to the original estimation (Table 2.18), the coefficients and the estimated semi-elasticities from the new estimation for the first-stage equation are higher in absolute terms for all the explanatory variables, while the signs stay the same (Table 2.21). To assume that transaction-costs rationing is an expression of quantity rationing (instead of a price-rationing mechanism) significantly increases the probability of a household being credit-constrained. There are 67 households that shift from being price-rationed to being quantity-rationed, due to transaction-costs rationing. In addition, variables such as the household head's age and the index of assets become statistically significant. The increased values of the estimated coefficients and the associated elasticities, while the signs remain the same, confirm that these variables affect the likelihood of being credit-rationed for a given household.

Variable	Coefficient	Semi elasticity	Average
Household head's age	-.204**	-10.77**	52.896
Household head's age squared	.002**	6.69**	3004.6
Bank deposits	-.995**	-0.273**	0.275
Microenterprises	-.478	-0.183	0.383
Assets index	-.078**	-0.719**	9.268
Land holdings	-.469***	-0.858***	1.831
Livestock value	-.118	-0.215	1.825
Distance to markets	-.001	-0.050	39.968
Year 2001	3.32***	1.601***	0.482
Constant	9.53***		
Rho	.985		
Observations	885		
Groups	468		
Wald chi2(9)	19.77		
Log likelihood	-343.413		

Table 2.21. Estimation of model about the rationing condition using a random-effects probit with transaction costs as a quantity rationing mechanism.

The effect of this modification on the second-stage results is less marked (see Table 2.22). Most of the coefficients keep the same sign as those from an estimation with the original classification of credit rationing. The magnitude of the coefficients varies, but this variation is, in general, not a drastic one. The difference between the coefficients –for most of the cases– is less than 20 percent. The degree of statistical

significance, however, does vary from one estimation to the other. In particular, in the new estimation the coefficient for income in its linear form loses significance. The same is true for the coefficient for family size. The variable related to formal loan size loses significance for the credit-rationed group, but it gains significance for the non-credit rationed group. This result is explained because the group of households shifting from non-constrained to credit-constrained has zero loan size (as they did not ask for credit because of the high costs of the loan contract), thereby reducing the variability in the credit constrained group and increasing the variability in the non-constrained group.

The difference in average for several variables between the two groups (credit constrained and non-constrained) is less acute than in the original specification, suggesting some mixing of households that before were more clearly separated.

Statistics for goodness of fit do not differ notoriously between the two approaches. The *R*-squared has the same pattern for within, between, and overall estimations. The Hausman test for the credit-constrained group becomes statistically significant, suggesting that the random-effects model produces a better fit.

In general, there is no strong evidence that this new classification does better than the original one. For the variables of interest, and given the theoretical framework, including transaction-cost rationing as a form of price rationing, seems to be a natural way of classifying households.

Variable	Credit constrained			Credit non-constrained		
	Coefficient	Elasticity	Average	Coefficient	Elasticity	Average
Income	.061*	.421*	5.938	.141	.721	7.253
Income squared	-.001	-.069	45.490	-.013***	-.642***	69.643
Household human capital	-.012	-.048	3.355	.030	.095	4.534
Family size	.020	.141	6.044	.040	.171	6.146
Land holdings	.122***	.269***	1.889	.083***	.210***	3.605
Assets index	-.004	-.044	8.558	.024*	.208*	12.046
Share of off-farm workers	-.212*	-.087*	.353	-.118	-.025	.298
Share of workers in						
microenterprise	-.070	-.009	.109	-.408	-.050	.174
Livestock value	-.008	-.021	2.277	.010	.016	2.396
Remittances	.002	.011	5.884	-.001	-.003	5.300
Index of crop						
diversification	.183***	.455***	2.128	.168***	.305***	2.579
Plot slope index	.046	.158	2.961	.086	.185	3.047
Use of technical						
assistance	.072	.005	.062	.087	.011	.183
Average inputs cost	-.106***	-.227***	1.836	-.009	-.022	3.542
Formal loan size	.036*	.022*	.535	-.013*	-.028*	3.111
Informal loan size	.009	.004	.333	-.016	-.006	.540
Year 2001	-.193***	-.123***	.544	-.257	-.069	.378
Lambda	-1.507***	-.542***	.308	-1.888**	-1.883**	1.413
Constant	.584**			2.556*		
Rho	.358			.643		
R-sq: within	0.252			0.508		
Between	0.447			0.299		
Overall	0.424			0.299		
Observations	390			164		
Groups	254			107		
Wald chi2(k)	244.42			86.30		
Breusch and Pagan Test	24.96***			5.49**		
Hausman Test	67.15***			47.49***		

Table 2.22. Estimation of a random-effects model for land utilization decisions conditional upon the credit condition with transaction costs as a quantity rationing mechanism.

Because high transaction costs are part of the price vector of the loan, as pointed out by González-Vega (1984), treating these households as quantity rationed may be misleading for the analysis of the impact of credit rationing on decisions about land use for cultivation.

2.8. Conclusions

Due to simultaneous interactions among several variables in the rural household's decision-making process, the relationships among access to credit, poverty, and land use are complex.

On the one hand, rural households make simultaneous consumption and production decisions. Moreover, production decisions involve a range of income-generating activities besides agricultural production. Non-agricultural opportunities, such as microenterprises and off-farm labor, are increasingly becoming important elements of income generation for rural households in El Salvador and other developing countries. These opportunities emerge as the rural areas become more integrated into global markets and households gain physical access to broader economic spaces, through an expansion of the transportation and communications network. Households can take advantage of the new opportunities as they improve their skills through formal and informal human capital formation. Globalization and market liberalization policies widely promoted during the 1990s have further expanded opportunities for rural households in developing countries.

The various opportunities sometimes are complements and sometimes are substitutes of agricultural production, depending on the binding constraints and endowments of the household. Some rural households have been able to adapt to the new opportunities and challenges, taking advantage of them. Others, due to limited endowments (in terms of both physical and human capital) have faced greater difficulties in responding to these new scenarios. They are finding it more difficult to escape poverty traps, where the least favored end up being less able to improve their living standards (Rodríguez-Meza and González-Vega, 2004).

As a result of these constraints, opportunities and threats, households make particular decisions about natural resource use. In countries like El Salvador, where deforestation has reached an advanced stage and where the use of land for agricultural purposes has expanded beyond reasonable limits, household decisions impinging upon natural resources imply a high opportunity cost, not only at a private but also at a social level. With such high pressures on land, the remaining forest-covered areas are valuable not only because of the non-timber products that households can obtain from them (mainly fuelwood), but also because these forests protect watersheds important for satisfying the water demands of an increasing population. In addition, these remaining plots are the least productive in agricultural terms –following Ricardian assumptions– and are the most fragile in terms of erosion and degradation. Therefore, household decisions about increasing their allocation of land for agricultural purposes imply a potential degradation of natural resources. In this essay, therefore, cropland decisions are

used as a proxy for environmental degradation. This assumption is valid for El Salvador and similar settings.

Access to credit plays an important role in shaping the set of constraints that households face and, in turn, their productive and resource use decisions. Additional use of land for agricultural purposes may be, under certain circumstances, encouraged as a response to increased access to credit. In other cases, the effect would be the opposite.

In this essay, I identify at least three channels through which access to credit may affect environmental outcomes. First, a *risk-coping* effect plays an important role, as households find in credit a useful tool to manage and cope with risk. As a tool for risk management, credit may induce changes in production strategies. Households with access to credit are usually expected to be more inclined to invest in agricultural intensification, which typically offers higher but more variable returns and therefore may appear as risky. Usually, intensification releases pressures on land. As a tool for coping with risk, rural households with access to more efficient strategies for consumption smoothing reduce their demand for land for precautionary motives. Therefore, this channel is expected to result in a beneficial effect of credit on resource conservation.

Second, increases in access to credit generate a *liquidity effect*. Through this channel, the liquidity constraint is pushed outwards and households are able to acquire more market inputs and capital goods. Their production choices become less credit-constrained. Which category of inputs and capital goods will be demanded depends on features of production functions and on the set of opportunities available to the household. A reduction in land use for agriculture would be expected if households favor

the purchase of non-agricultural capital goods (*e.g.*, investment in microenterprises). If decisions favor capital goods for agriculture, the effect will depend in part on the existence of returns to scale and of indivisibilities related to the underlying technologies. Depending on these circumstances, a less binding liquidity constraint may induce intensification (with beneficial effects on conservation) or extensification (with adverse effects). Theoretically, the final outcome on natural resource conservation will be ambiguous.

A third channel is the *income and wealth effect*. Households with access to credit that enhance their income-generating abilities will increase their wealth over time. Part of this wealth may be accumulated in the form of land. A larger demand for land, as wealth increases, emerges for several reasons, including investment and precautionary purposes or the accumulation of inflation hedges. The net result on conservation will depend on the uses of the newly acquired land. In several Latin American countries, this wealth effect is reflected in the expansion of grazing land and livestock, which usually are associated with resource degradation. Moreover, households may be encouraged to allocate additional resources to livestock, as this is a potentially collateralizable asset, which will let them gain further access to credit.

In the end, if the theoretical predictions are ambiguous, the actual net effect of access to credit on natural resource use will be an empirical issue.

Using rural household data for El Salvador, results from the empirical tests confirm these hypotheses. After analyzing their status in terms of credit rationing, households from the sample were divided into different categories, reflecting their

degrees of access to formal credit: (i) price rationed with loan (7 percent), (ii) price rationed without loan (30 percent), (iii) partially quantity rationed (1 percent), and (iv) fully quantity rationed (62 percent). For estimation purposes, the first three categories were merged into a class of price-rationed or non-credit constrained households, while category four represented quantity-rationed households or credit-constrained households.

Using the panel data for 1999 and 2001, one of the predictions of González-Vega (1976) implicit in the iron law of interest rate restrictions is confirmed for El Salvador: households with smaller endowments are more likely to be rationed in formal credit markets than more endowed households. This seems to be especially true for groups in the second and third quintiles of the income distribution. The poorest households of the sample (first quintile), although highly rationed, are not as rationed as the second and third groups. This may reflect the fact that the poorest households do not have enough productive opportunities to generate a legitimate demand for credit and that, therefore, they are subject to price rationing and not to quantity rationing. This finding offers insights that contribute to the long standing debate about the best way to offer credit to the poorest of the poor, if at all. The point of view of the Rural Finance Program at Ohio State, that success in outreach should not be measured in terms of the supply of loans to the poorest but only in terms of a supply to those who demand and are able to repay these loans, is reinforced by this result.

Households in the mid-low and mid incomes quintiles usually have unexploited productive opportunities and some human and physical capital but not enough to take full advantage of them. Moreover, their holdings of physical capital may not be enough

to satisfy collateral requirements and the screening criteria of lenders. Therefore, they do not achieve the creditworthiness required and become quantity rationed.

A switching regressions model is used to test for the impact of access to credit on land use. In the first stage, a probit random-effects model is used to test for the probability of a household being rationed. In the second stage, two separate regressions are run, one for each group of households (credit constrained and non-credit constrained). Differences between the two groups are significant for both the mean of most of the explanatory variables used and the coefficient estimates. This observation confirms that, given different sets of constraints, credit-rationed households differ systematically, in terms of their decisions, from non-rationed households and in the way that access to credit shapes these decisions. The allocation of land to agricultural purposes is not the exception.

CHAPTER 3

THE INFLUENCE OF MICROFINANCE ON THE EDUCATION DECISIONS OF RURAL HOUSEHOLDS: EVIDENCE FROM BOLIVIA

3.1. Introduction

Increased access to education will be key in any efforts to improve the quality of rural life and the welfare of the next generation in developing countries. Microfinance programs have been among components of strategies for poverty alleviation that have attempted to address this challenge. This essay uses data from three different surveys of households of clients of microfinance organizations (MFOs) in Bolivia to examine several channels through which microfinance may exert an influence on education outcomes. Five channels are identified, designated as income, risk-management, child-labor demand, gender, and information effects.

Based on an econometric specification that explains schooling decisions at the household level, regression models are used to examine determinants of education achievements and to make inferences about the potential influence of microfinance, through these channels, on those achievements.

The results challenge usual assumptions in microfinance programs. In particular, for some ranges of household income and some types of borrowers, access to loans has conflicting effects on school enrollment. On the one hand, loans increase the demand for education as a result of income, risk-management, gender, and information effects. On the other hand, credit-constrained households that cultivate land or operate labor-intensive microenterprises discover new demands for child labor, either for farming, working in the microenterprise, or taking care of siblings while the mothers operate the new or expanded business. Significant program and policy consequences are derived from these paradoxical results.

3.2. Motivation

To alleviate poverty is one of the most significant challenges for developing countries in the current century. Human capital formation has been recognized as an effective tool for reducing poverty in the long run (Schultz, 1961; Bils and Klenow, 2000; Krueger and Lindahl, 2000). Particularly in the rural areas of developing countries, however, access to education is limited (Barro and Jong-Wha, 2000). Some concerned observers highlight supply constraints, due to lack of infrastructure and resources (*e.g.*, roads, schools, teachers and materials). Low schooling achievements may also reflect, however, the consequences, on the demand for education, of severe budget constraints and of a competing demand for the youth's labor.

In particular, the demand for education depends both on household preferences and on budget constraints that are influenced by income levels. If a sufficiently high

marginal value is placed on the education of family members, increases in income will result in higher expenditures in schooling. That is, there is a positive income elasticity of the demand for education. For some ranges of income, this elasticity may be even greater than one, with expenditures in education increasing at a faster rate than income.

In turn, given the labor-supply potential of children, a low household income implies a high opportunity cost of keeping them in school. In particular, the marginal utility of one extra unit of income may be higher for a poor household, in which case this opportunity cost is higher for a poorer than a richer household. Therefore, income levels are expected to positively influence the schooling decisions of poor households, while adverse shocks that reduce income are expected to negatively influence these decisions. At the same time, because the higher productivity of better-educated household members may be rewarded in the labor market with higher incomes, prospects about production and employment opportunities will influence those decisions (Duryea and Pagés, 2002).

Child labor may be demanded either to fulfill the household's basic income-generating requirements or to take care of younger siblings, so as to facilitate the labor efforts of more productive household members. Further, differential schooling outcomes may reflect cultural factors (*e.g.*, the traditional division of labor and expectations about gender roles as well as differences in male-female preferences).

Financial services (loans, payments instruments, and deposit facilities) allow households to take fuller advantage of their productive opportunities, facilitate consumption smoothing in the presence of unstable and seasonal income flows, and offer tools for risk management when adverse income shocks occur, thereby reducing the

vulnerability associated with poverty (Sharma and Zeller, 1999). In turn, higher and particularly more stable income flows positively influence the demand for schooling.

Typically, however, information, incentive, and contract enforcement problems severely constrain the access of poor rural households to formal financial markets (González-Vega, 2003). Moreover, because human capital cannot be seized and transferred to a lender in the event of default, it cannot be used as collateral; consequently, the poor must fund their educational choices out of their past wealth, retained earnings, or abstention from current productive work or consumption. Because they are poor, the marginal cost of doing so may be prohibitively high (Ray, 1998).

The typical shortcomings of credit markets accentuate the joint causation between income and human capital. Combined with increasing returns to investment in education, these shortcomings generate poverty traps (Bardhan and Udry, 1999). Relatively wealthy households, able to invest in human capital, earn high incomes and remain wealthy. In contrast, the poor are unable to invest in human capital, continue to earn low incomes, and remain poor.

Through innovations in cost-effective lending technologies, microfinance organizations (MFOs) have been offering mostly credit and sometimes deposit facilities for savings to segments of the rural population otherwise without access to formal finance (Rodríguez-Meza and González-Vega, 2003; Quirós, Rodríguez-Meza and González-Vega, 2003; Navajas and González-Vega, 2003). These innovations have allowed households without traditional collateral to pledge their reputation in the community and the present value of their relationship with the MFO –based on their

future ability to generate income from their microenterprises and on their human capital formation— as a guarantee on their loans. Some observers have hoped that this might be an important mechanism to influence, directly or indirectly, outcomes about education.

The available literature has identified different channels through which microfinance may influence human capital formation. In this essay, these effects and some new ones are grouped into five categories.

First, it is widely recognized that income levels influence schooling (Behrman and Knowles, 1999). Changes in income modify the ability of households to afford the opportunity costs of education. To the extent to which microfinance may influence the growth of the incomes of poor households, it may influence the demand for schooling (*income effect*).

Second, the vulnerability of rural households to adverse exogenous shocks and the volatility of their incomes not only influence their ability to afford the opportunity costs of education but also force them to engage in risk-coping strategies that may require pulling their children out of school and do not allow sustained enrollment over time. This outcome may be transitory, unless there are poverty traps, either because school expenses can no longer be afforded or because the children are needed to earn extra income indefinitely. The absence of the usual remedies for risk, such as borrowing and insurance benefits results in the adoption of costly income smoothing strategies (Deaton, 1997). In order to cope with risk, poor households frequently adopt diversified production plans and employment and migration strategies, even if these actions entail lower average incomes (Morduch, 1995). In addition, households smooth consumption

by using financial savings, selling assets, taking children out of school, and developing informal insurance and credit arrangements (Kanbur and Squire, 2001). Access to loans from MFOs –particularly when emergency loans are offered, such as those from the internal account of village banks– reduce the probability that children will be withdrawn from school when adverse shocks occur.

Jacoby and Skoufias (1997), among others, show how poor households affected by income shocks withdraw their children from school: a ten-percent decline in agricultural income across seasons caused a fall in school attendance of five days in a sample of six Indian villages. Access to microfinance may thus improve a household's ability to anticipate and cope with income shocks and may thereby positively influence the demand for education (*risk-management effect*).

Third, several studies have hypothesized that, compared to men, women show a stronger preference for educating their children (Thomas, 1990; Behrman and Rosenzweig, 2002; Sallee, 2002). If preferences toward education are gender-related and if microfinance improves access to loans by women and, thereby, changes their power to influence household schooling decisions, the rate of human capital formation may be altered by access to these services (*gender effect*). This approach substitutes a bargaining process within the household for the traditional unitary model of optimization of a single preference set (Haddad, Hoddinott, and Alderman, 1997). The outcome of this bargaining process reflects gender differences both in preference functions and in relative power in influencing household decisions (Phipps and Burton, 1995; McElroy, 1997; Nanda, 1999).

Fourth, given uncertainty about the future, imperfect information about opportunities, and high private discount rates, in large part due to poverty, household choices about education may be shortsighted. These choices may be revised with the acquisition of new knowledge that either modifies intertemporal preferences or changes perceptions about the value of schooling. If access to microfinance changes perceptions about opportunities or allows learning about potential returns, it may have this impact (*information effect*). In effect, higher levels of the education of the parents have been found to positively affect schooling decisions (Lillard and Willis, 1994).

In particular, preferences about schooling may be influenced by adult training programs that highlight education as a tool for income generation or as a determinant of the standards of living. Some MFOs, as is the case of CRECER and Pro Mujer in Bolivia, hold meetings with their borrowers on a regular basis and take advantage of these meetings to disseminate information about healthy reproduction, nutrition, and child education, among others. The influence of these credit-cum-education programs in improving standards of living is subject to great debate (MkNelly and Dunford, 1999; Littlefield, Morduch and Hashemi, 2003).

An additional and important debate questions the optimality, from an organizational perspective, of jointly providing credit and other non-financial services. On the one hand, there may be economies of scope for both provider and client from this joint provision. On the other hand, the supply of non-financial services may jeopardize the pursuit of financial sustainability by the MFO, through diseconomies from overburdening the organization's management capabilities or from signals that weaken

borrower discipline and willingness to repay (González-Vega, 1998; Rhyne and Otero, 1992). The present essay does not address these issues.

The analysis is, in this respect, incomplete, in that it only assesses the marginal value of the supply of credit-cum-education services, but it does not measure the marginal cost of providing these services. These organizations may actually face a trade-off between successfully offering non-financial services and a package of fairly simple (rudimentary but still valuable) financial services versus offering a broader and more diversified menu of just financial services, as other MFOs do (Quirós, Rodríguez-Meza and González-Vega, 2003). Moreover, the cost-benefit evaluation of these approaches must take into account the initial conditions of the target segment of the population and the existing government infrastructure for the delivery of these services.

Fifth, there is a growing literature on the influence of the demand for child labor on schooling outcomes (Psacharopoulos, 1997; Jensen and Nielsen, 1997; Patrinos and Psacharopoulos, 1997; Grootaert and Patrinos, 1999; Trigueros, 2002). Additional productive activities, made possible by access to microfinance, may change household demands for child labor directly, in the newly-created or expanded microenterprises, or indirectly, in child care or in farm and livestock duties, and other household chores (*child-labor demand effect*).

The purpose of this essay is to evaluate the influence of microfinance on human capital formation by looking at whether children from rural households with access to just credit or to credit-cum-education programs are kept longer in school than children from households with no access to these programs.

3.3. Methodology

The assessment of impact, which involves attributing specific effects to specific interventions, encounters formidable methodological problems (Ravallion, 2001). Meyer (2002) claims that the measurement and attribution of impacts of microfinance on clients is the most difficult and controversial aspect in the evaluation of the performance of MFOs. To illustrate these problems, following Ravallion (2001), denote P_i as the participation of the household in the program (for instance, the parent of the i th child gains access to microfinance services), where $P_i = 1$ if the child's parent participates and $P_i = 0$ if he/she does not. If the household does not participate, the child's education outcome is S_{0i} . If the household participates, the education outcome for the child is S_{1i} . The gain in education achievement, G_i , due to participation in the microfinance program for a household that does in fact participate is:

$$G_i = S_{1i} - S_{0i} \mid P_i = 1 \quad (3.1)$$

An unbiased estimate of the true mean gain in education achievement will be:

$$G = E(S_{1i} - S_{0i} \mid P_i = 1) \quad (3.2)$$

This gain is the average increase in schooling for those households that participate in the microfinance program compared to those that do not. From the available information, however, one is usually not able to calculate G . Instead, information is available on the outcome for children from participating families and for children from non-participating families. To obtain an estimate of the gain, D , one can set:

$$D = E(S_{1i} | P_i = 1) - E(S_{0i} | P_i = 0) \quad (3.3)$$

There is a simple identity relating G and D , given by

$$D = G + B \quad (3.4)$$

where B refers to the bias in the estimate. This bias is given by

$$B = E(S_{0i} | P_i = 1) - E(S_{0i} | P_i = 0) \quad (3.5)$$

The bias is the expected difference in outcome (schooling) without treatment (participation in the microfinance program) between households that did in fact participate and those that did not. The bias could be corrected if one knew $E(S_{0i} | P_i = 1)$, but there is no way of having a sample estimate of this magnitude: one cannot observe what the performance would have been for children whose families actually participated in the program, had they not participated. The bias arises if there is a difference in mean outcome between the treatment and non-treatment groups in the absence of the program; that is, if there would have been a difference between the outcome of children from borrowing and children from non-borrowing families in the absence of microfinance services, due to some other unobserved circumstances, such as the parents' drive, or to other reasons.

Therefore, one important dimension of these difficulties, of relevance here, is the possibility of selection bias. Both the selection of clients and program placement are sources of concern. The first concern arises because MFO clients will not likely be randomly selected; rather, they possess characteristics that are systematically different from those of a randomly selected sample and, therefore, also of non-participants.

Self-selection into the program can occur because of systematic differences in preferences among those who choose to participate and those who do not. Moreover, if the lender uses a systematic creditworthiness-screening criterion, borrowers should differ from non-borrowers. Non-participants, therefore, are a non-equivalent comparison group. Ignoring this source of potential endogeneity can lead to biases due to the omission of unobserved relevant variables (Moffitt, 1991).

A second concern arises because MFOs choose to start operations in areas with specific attributes, such as communication and transportation facilities or conglomerates of target clienteles (Pitt and Khandker, 1998). Programs may be developed in localities that are either more dynamic than others are or where the incidence of poverty is greater. Unmeasured locality factors and household attributes may simultaneously affect the demand for program participation, women's empowerment, and the demand for education. This possibility of selection bias implies a difficulty to determine if differences between groups are due to the supply of microfinance services or to non-representative clients and locations.

To face the problem of selection bias, it is desirable to identify what would have happened without participation; that is, we need to use an appropriate comparison group. This group is designed to be representative of the treatment group of participants, with the only difference being that the comparison group did not participate in the program. To accomplish this, different approaches may be available:

- *Randomization.* The selection into the treatment and comparison groups would be random among some well-defined set of people. In this way, the only

difference between the two groups would be due to the participation decision. However, given screening and program targeting (*e.g.*, MFOs focusing on certain groups), participation is unlikely to be unbiased.

- *Matching*. The comparison group is matched to the treatment group on the basis of a set of observed characteristics or using the propensity score (that is, the predicted probability of participation, given observed characteristics).
- *Reflexive comparisons*. A baseline survey of participants is undertaken before the intervention, and a follow-up survey is implemented afterwards. The baseline provides the comparison group, and impact is measured by the change in outcome indicators before and after participation.
- *Double difference methods*. Treatment and comparison groups are compared (first difference) before and after a program (second difference).
- *Instrumental variables method*. Variables that matter for participation but not to outcomes given participation are used. These variables, if they exist, identify a source of exogenous variation in outcomes attributable to the program. Instrumental variables are first used to predict program participation, and then an outcome indicator is evaluated as a response to predicted values.

The feasibility of some of these methods may be limited by different circumstances. For instance, they may be too costly, and to obtain the desired information may be too difficult or impossible to accomplish.

Following Ravallion (2001) and Heckman (1997), there is an econometric design that can be useful to capture the differences between groups relevant for the test.

Suppose a regression model is estimated, where the dependent variable is the outcome to evaluate (S_i). The independent variables should include participation in the program (P_i) and control variables (X_i) related to the individual, the family, and the environment. Therefore, the specification would be:

$$S_i = \alpha + \beta P_i + \gamma X_i + \varepsilon_i \quad (3.6)$$

It is expected that β accounts for the difference due to the program. However, this regression does not allow the impact of the program to vary with X . That is, impact is the same for everyone, which may not be the case if one expects differences between groups beyond actual participation. To face this possibility, let the mean outcome for non-participants be $\alpha_0 + \gamma_0 X_i$ and the mean outcome for participants $\alpha_1 + \gamma_1 X_i$, such that

$$S_i = (\alpha_1 + \gamma_1 X_i + \varepsilon_{i1})P_i + (\alpha_0 + \gamma_0 X_i + \varepsilon_{i0})(1 - P_i) \quad (3.7)$$

where ε_0 and ε_1 are random errors with mean zero and uncorrelated with X . This equation can be written as

$$S_i = \alpha_0 + (\alpha_1 - \alpha_0)P_i + \gamma_0 X_i + (\gamma_1 - \gamma_0)X_i P_i + \varepsilon_i \quad (3.8)$$

and the impact of the program for individual i would be

$$\frac{\partial S_i}{\partial P} = (\alpha_1 - \alpha_0) + (\gamma_1 - \gamma_0)X_i \quad (3.9)$$

This allows computation of the mean program impact for the whole sample. If the right-hand side (RHS) variables are not exogenous, however, OLS estimates of the parameter will be biased even in large samples. That is, the RHS variables must be

determined independently of the outcome-decisions choices, so that they are uncorrelated with the error term in the regression.

For the samples analyzed here, due to non-random placement, the estimation results may be biased. The implicit assumption is that ε_i is independent of P_i , but some unobservable characteristics accumulated in ε_i are not independent of participation decisions. To be sure that the results are still valid, the instrumental variables approach must be used. Suppose participation can be expressed as

$$P_i = \phi + \theta Z_i + \eta_i \quad (3.10)$$

where Z_i is a set of variables that includes all the variables used in targeting clients by the MFO placement decisions. If X includes all the variables in Z that also influence the outcome, and the error term η is uncorrelated with the error term ε , an OLS regression will generate an unbiased estimate of β . This method is called *selection on observables* (Heckman and Robb, 1985). However, it only works if the initial assumptions hold: (i) That there are no unobserved determinants of participation, and (ii) that ε contains variables not available in the survey but that do affect the participation in the program. These variables may be correlated with η , and ε will not have zero mean, given X and P . In the end, there will be correlation between ε and η . Given the threat of self-selection bias before the sample is collected, there is some risk of still obtaining a bias in the estimates.

The use of instrumental variables, which is the classic solution for the problem of an endogenous regressor, is based on the inclusion of some observable source of exogenous variation in program participation. That is, this source of variation is

correlated with P but it is not already in the regression for the outcome and it is not correlated with the error term ε . This implies that one needs at least one variable in Z that is not in X and that is not correlated with ε . Then, the instrumental variables estimate of the program's impact is obtained by replacing P by its predicted value, conditional on Z . Since the predicted values depend only on the exogenous variation due to the instrumental variable as well as on the other exogenous variables, the unobservable variables are no longer a problem, since they will be uncorrelated with the error term in the regression for the outcome.

Because the source of bias in the estimate of impact is the correlation between the error term in the outcome equation and the error term in the participation equation, a common practice is to add the residuals from the first-stage equation for participation to the equation for outcome. In this way, the actual participation variable is in the outcome regression and, because the error term estimate has been added to the outcome regression, participation can be treated as exogenous and OLS can be used (Ravallion, 2001).

Given severe information constraints, this essay modestly attempts to minimize potential selection problems. The issues were addressed by using a cohort approach in the sampling process, with results similar to those from reflexive comparisons. Participants were controlled according to their seniority; that is, their length of permanence as clients of the MFO. From this perspective, they were separated into *old* clients, with more than one year in the program, for whom benefits (such as education impacts) would have already accrued, and *new* clients, with one year or less of

participation, who have successfully passed the credit screening mechanism but for whom benefits would not have yet accrued. Therefore, the key assumption is that those who have been members of the program for a short period (*i.e.*, less than a year) have not had enough time to increase their incomes or change their attitudes toward schooling and the expected results will not be observed. They are a control group for comparison to households with members who have received credit and non-formal education for longer periods. Self-selection may still be present, nevertheless, if older participants possess unobserved features that differ in degree from those of more recent participants. This could be the case, for example, if the organization's screening criteria have changed in ways that influence non-observed variables.

When dividing the sample into *old* clients (more than one year of permanence as a client) and *new* clients, I control for those variables that are unobservable but that induce participants to become clients, with the advantage that new clients have not yet been exposed to the benefits of the microfinance program, while old clients have. In this way, the inference that schooling differences between the children of old and new clients –after controlling for demographic and environmental variables– are the effect of the program is a reasonable inference as is the expectation that these estimates are unbiased. These results cannot be compared, however, with the performance of non participants, as there is no information about them in the surveys.

3.4. The Model

Based on Schultz (1993), Lardé de Palomo and Argüello de Morera (2000) recognize that in developing countries, the late incorporation of children to the schooling system and their early withdrawal are mostly due to demand factors. When parents decide about their children's schooling, they choose to allocate a fraction of household income to education, according to the profitability of schooling that they perceive. This perception depends, in turn, on the parents' own level of education and on features of the economic environment. Credit-cum-education programs may influence these perceptions. Behrman, Pollack, and Taubman (1986) further argue that resources for education are split according to the number of children, their gender, and their age, given household composition and the severity of the budget constraint.

In the rural areas of developing countries, moreover, the demand for schooling is influenced by determinants of other forms of human capital that may substitute for or complement education and that are influenced by microfinance-cum-education programs (such as health and nutrition), by productivity gains and the diversification of the sources of labor income (also influenced by access to microfinance), by flows of non-labor income, such as subsidies and remittances, and by the ownership of assets that can be used as collateral for loans. Khandker (1998) found that, in Bangladesh, microloans had a significant impact on the children's schooling, especially for boys. This finding would imply that the child's gender may also matter. Indeed, for all low-income countries, Ray (1998) notes that, in 1995, there were almost twice as many female as there were male illiterates.

For the analysis of this essay, it is assumed that parents make decisions about sending their children to school from the perspective of a long-run investment. Several authors have modeled schooling as an investment decision that generates a flow of benefits and costs over time (Becker, 1993; Glick and Sahn, 2000). Given a household rate of time discount and other particular characteristics, each household perceives an expected net present value from the decision about educating their children.

Let us start by assuming a simple household, whose members can be divided into three groups: adults who work, children that can either work or attend school, and younger children that cannot work. For the simplest case, assume that the adults are uneducated. This assumption could be relaxed as an extension of the model but it is kept here for the sake of simplicity and without loss of generality.

In the first period ($t=0$) of a simple two-period model, the household invests in the education of its children. In the second period ($t=1$), the children grow up and the household reaps the benefits. In addition to spending on education for each child in school (E), the household consumes goods and services, during both periods, (C_0 and C_1).

The sources of income are earnings from household labor (L), supplied by adults (who are uneducated) and children able to work. Labor can be sold at a wage rate w for non-educated household members. Here, the assumption is that the unskilled-labor wage rate is the same for adults and for children able to work (teenagers). This assumption might not be true for some activities and it matters, as the opportunity cost of educating

them will be less if the teenager wage rate is lower. It could also be relaxed as an extension of the model.

If the household decides to educate some of the potentially-working children, a proportion of the labor force, α , will not be available to generate income in period $t=0$. In period $t=1$, however, this educated portion of the labor force will earn a higher wage rate w' ($w' > w$). Therefore, in period $t=0$, income will be equal to $[(1-\alpha) w L]$; in period $t=1$, income will be $[(1-\alpha) w L + \alpha w' L]$. Assuming a composite good C , with price $p=1$, expenditures in period $t=0$ will be $[C_0 + \alpha E]$ and in period $t=1$ they will be $[C_1]$. Consumption is the result of the sum of consumption of the three-groups: adults, children able to work (teenagers), and young children. The model could be extended to deal with the shares of consumption for each group and with per capita consumption. In this way, dependence issues could be addressed.

During period $t=0$, either if income is low or if education expenditures are high, a small proportion of the children will go to school. At the same time, however, low income due to low wage rates reduces the opportunity cost of sending children to school, increasing their likelihood of being educated.

Assume that the household gains access to a loan B , to be repaid in the second period, given an interest rate and borrower transaction costs. It is assumed that the loan has no productive impact and that its usefulness comes from its ability to facilitate the household's inter-temporal allocation of resources. Credit used to face exogenous shocks is not included in this model either. Define r as the sum of the interest rate and *per peso* transaction costs.

Thus, the cash flow constraint for period $t=0$ becomes $[(1-\alpha)wL + B]$, and expenditures for period $t=1$ become $[C_1 + (1+r)B]$.

Utility comes only from consumption (C_0, C_1) . The problem for the household is to choose the level of consumption for each period, C_b , the rate of schooling of the children α , and the optimal loan size B , in order to

$$\begin{aligned} \text{Max}_{C_0, C_1, \alpha, B} U(C_0, \rho C_1) \quad \text{s.t.} \quad & (1-\alpha)wL + B = C_0 + \alpha E; \\ & (1-\alpha)wL + \alpha w' L = C_1 + (1+r)B \end{aligned} \quad (3.11)$$

Here ρ is the intertemporal discount factor, given by $(1/(1+\delta))$, and δ is the time discount rate for the household. Solving for C_0 and C_1 in the budget restrictions and substituting into the utility function, the problem becomes

$$\max_{\alpha, B} U\{(1-\alpha)wL + B - \alpha E, \rho[(1-\alpha)wL + \alpha w' L - (1+r)B]\} \quad (3.12)$$

The first-order conditions for an optimum are given by

$$\frac{dU}{dC_0}(wL + E) = \rho \frac{dU}{dC_1} L(w' - w) \quad (3.13)$$

$$\frac{dU}{dC_0} = \rho \frac{dU}{dC_1} (1+r) \quad (3.14)$$

The first condition indicates that the marginal utility of current consumption, weighted by the sum of education expenses per child in school and forgone income from the last unit of labor used (LHS), which can be interpreted as the marginal cost of devoting a proportion α of the household's labor force to an investment in education, should equal the discounted marginal utility of future consumption, weighted by the difference between earnings from wage rates for skilled and unskilled labor for the last

unit of labor used (RHS), which can be interpreted as the discounted marginal benefit of educating a proportion α of the household's labor force. Calculating the intertemporal marginal rate of substitution,

$$\frac{\frac{\partial U(.)}{\partial C_0}}{\frac{\partial U(.)}{\partial C_1}} = \rho \frac{L(w'-w)}{wL + E} \cong \frac{\Delta C_1}{\Delta C_0} \quad (3.15)$$

The household would be more willing to give up current consumption for the sake of future consumption, the greater the salary gap between educated and non-educated workers (that is, the marginal rate of return on education), the lower the opportunity cost of sending one person to school (that is, the wage rate for non-educated workers), and the lower the expenses needed for school attendance. The propensity to send children to school (α) will be increasing in salary differentials ($w'-w$) and decreasing in the salaries of the non-educated (w) and the costs of attendance per pupil (E).

The second condition implies that the marginal utility of the additional purchasing power from the consumption-and-education loan in the initial period (LHS) should equal the discounted marginal disutility of the corresponding loan repayment, given borrower transaction costs and interest rates (RHS).

In order to incorporate *gender effects* in the model, assume that the household's utility can be written as a Cobb-Douglas function, where the shares correspond to weights for females and males in the household involved in making decisions about the households' levels of consumption. If γ represents the proportion of women decision

makers in the household and $(1-\gamma)$ the proportion of men, the household's utility function can be written as:

$$U(.) = U_F^\gamma U_M^{1-\gamma} \quad (3.16)$$

This specification makes it possible to include differential preferences between women and men within the family. Assuming that women have a stronger preference than men about schooling, when women gain access to decision-making within the household, these preferences will be reflected in the consumption patterns as well as in the investment in education.

The model accounts for the expected effects of microfinance on schooling decisions. The household's labor supply $(1-\alpha)L$ and the wage levels for skilled and unskilled workers (w and w') determine levels of income as well as marginal returns on education, while α accounts for the demand for child labor. Note that household size can play an important role in this framework. With a greater share of adults generating income from labor, children will be more likely to be educated. In the same way, the greater the number of children able to work, the more likely for some of them to be educated, and the higher the share of them sent to school.

In this context, the presence of B in the budget constraint accounts for a consumption reallocation effect (as the loan facilitates an intertemporal reallocation of resources) and for investment in human capital formation. So far, the model does not say anything about the impact of credit on the household's productivity (income smoothing) or the use of credit to overcome shocks (consumption smoothing). Another limitation of this simple model is that it does not include credit rationing as a usual binding constraint

for poor households. These issues can be addressed in posterior studies. Finally, the shares γ and $(1-\gamma)$ in the utility function account for the gender effect, while the specific functional form can capture the information effect on preferences about education.

Using the implicit function theorem, the first-order conditions imply that optimal demand functions for education and credit exist, namely

$$\alpha = \alpha(w, w', E, r; L, \gamma, \rho) \quad (3.17)$$

$$B = B(w, w', E, r; L, \gamma, \rho) \quad (3.18)$$

The outcome of this decision-making process determines the optimal proportion of the household's potential labor force to be kept out of work and into education and the optimal size of loan to be demanded, as functions of the opportunity cost of education (wage-earning activities), expected future income, education expenses, and the cost of credit, given parameters about household size, the importance of women in the decision-making exercise, and the time discount rate.

3.5. Econometric Approach

From the conceptual analysis, several key variables considered by households when making decisions about sending their children to school are identified. With this framework –and taking into account the identification and attribution issues that may emerge– an econometric specification is necessary to test empirically for the evaluation of impact on schooling of access to microfinance services.

From the derived demand for education, we observe that the household decides on the amount of education by looking at the current marginal costs and (expected) future marginal benefits of education. The household's decision is, however, taken on an individual basis. The household will decide to educate a particular child –able to work– if the present value of (expected) net benefits that he/she will accrue is positive. Otherwise, he/she will work.

The net expected utility from education may be expressed as a function of a vector of household and child characteristics (z), observed by the researcher, and of a stochastic component of preferences, known to the household but not observed by the researcher (ε). Then, the expected net present value of schooling for a given child in the household (denoted by i) can be written as

$$\text{ENPV}_i = f(z_i, \varepsilon_i) \quad (3.19)$$

This latent result cannot be measured. In its place, proxies for the potential determinants of the ENPV of schooling must be used. Further, given uncertainty about functional form and about unknown parameters, we must reinterpret the model in terms of probabilities: the probability that a child will be sent to school is the probability that his/her parents think that the household will be better off if he/she is studying:

$$\Pr(\text{schooling}_i) = \Pr[f(z_i, \varepsilon_i) > 0] \quad (3.20)$$

Using the approach of the random utility model (RUM) and assuming the function f to be additively separable in deterministic and stochastic components (Haab and McConnell, 2002), the expected net present value of schooling can be written as:

$$f(z_i, \varepsilon_i) = h(z_i) + \varepsilon_i \quad (3.21)$$

Then, the probability of schooling can be rewritten as:

$$\Pr(\text{schooling}_i) = \Pr(h(z_i) > \varepsilon_i) \quad (3.22)$$

According to the RUM, we can regress a binary dependent variable ($y_i = 1$ if the child is studying, $y_i = 0$ if the child is not studying) against the vector of observable and deterministic variables z_i .

In order to consider the possibility that, if the child is attending school this year, it does not mean that he/she had been able to attend continuously during previous years, a more dynamic framework is needed to capture the accumulated performance of each child.

The dependent variable capturing this effect and used for the empirical estimation of the model is the *education gap*, measured as the number of years of the difference between the highest level of education actually completed by the child and the expected level of education, according to the child's age. The expected level of education is calculated as:

$$\text{Expected education} = \begin{cases} 0 & \text{if } age \leq 6 \\ (age - 6) & \text{if } 7 \leq age \leq 18 \\ 12 & \text{if } age > 18 \end{cases} \quad (3.23)$$

The education gap is then defined as:

$$\text{Education gap} = \max \{0, \text{expected education} - \text{actual education}\} \quad (3.24)$$

For example, if a grown-up child successfully stayed at school up to the end of secondary education, the gap is zero. If she/he encountered problems (such as late entry, failed grades, or desertion), the gap is a positive number. If she/he never attended school, the gap is the level of expected education according to her/his age. As

attendance to primary school is widespread, only children between 13 and 18 years old are considered in the analysis.

Because the dependent variable is a positive integer number, the estimation is specified as a count model, rather than as ordinary least squares, as the latter may generate inefficient estimates. The *Poisson regression model* has been widely used to study such data (Wooldridge, 1997; Cameron and Trivedi, 1998; Greene, 2000). A source of criticism for these models is the implicit assumption that the variance of the dependent variable equals its mean. Many extensions of the Poisson model relaxing this assumption have been proposed by Hausman, Hall and Griliches (1984) and Cameron and Trivedi (1986), among others. The standard method to test and correct for over-dispersion is the use of a *negative binomial regression model*, which is a Poisson maximum likelihood regression with over-dispersion model.

The vector z includes variables required by the model and some control variables. These variables can be grouped into three categories:

Individual variables. They refer to specific characteristics for each child. These are control variables expected to influence education achievements:

- **Age.** This variable measures the child's age in years. The expected sign is positive; the older the child, the more likely that she/he will show an education gap.
- **Gender.** This is an instrumental (dummy) variable that takes the value of zero if the child is a boy and the value of one if the child is a girl. The expected sign is positive, under the hypothesis that, within the culture, the

value of the girls' education is less than the value of the boys' education; girls should show a larger education gap.

- **Position.** This variable assigns the value of one to the oldest child in the household, two to the next, and so on. When there are granddaughters/grandsons in the household, the value of one is again assigned to the oldest child, two to the second one, and so on. A positive relationship between this variable and the gap is expected, under the assumption that the oldest children are more likely to be kept in school than the younger ones.

Household variables. They are characteristics shared by all of the children within a household. Some of them are needed for control and others reflect specific effects to be tested for. As for control, the variables used are the **distance to school**, the **human capital of household workers**, and the **index of basic needs satisfaction**. The two later variables are also used to indirectly test for the presence of poverty traps in the education process. The level of schooling of working household members, a proxy for the stock of human wealth, is expected to improve the educational achievements of children. This variable can be used to reflect the household's income-earning capacity as well as perceptions about returns to education. The index of basic needs satisfaction is a proxy for access to health facilities and other public services, such as potable water (*i.e.*, social wealth). A more detailed description of these variables is:

- **Distance to school.** This variable is measured as the number of minutes needed to go from the house to the nearest high school. It is expected to have

a positive relationship with the education gap, as the further the school is, the less likely that the child attends it.

- **Human capital.** This variable is measured as the number of years of schooling accumulated by the workers of the household divided by the number of workers. The expected sign is negative, under the hypothesis that if the workers (who usually make decisions about the children's education) have higher levels of education, they will have a stronger preference for schooling and the gap will be smaller. Also, the level of the workers' human capital is an indicator of their income-generating capacity and, therefore, of their ability to pay for education expenses. This variable in part incorporates income effects and information effects.
- **Poverty index.** This variable is based on the poverty index used in Navajas *et al.* (2000), adopted from the *1992 Mapa de Pobreza* for Bolivia. For each household, the index of minimum satisfaction of basic needs (health, access to public services, such as water and electricity, housing materials and overcrowding, and literacy and education) was used here with a special adjustment; the education component of the original index was dropped, in order to avoid endogeneity problems in the estimation (See González-González and González-Vega (2004) for a detailed discussion of the index). The expected sign is negative; the higher the index of basic needs satisfaction, the less poor the household is estimated to be, and the smaller the expected education gap will be. The assumption is that greater poverty

increases the opportunity cost of keeping children at school and that it also reduces the prospective yields of education.

The variables used in order to test for other channels of impact comprise (i) the **length of membership** of the client as a borrower of the MFO, (ii) the use of the **internal account**, (iii) the **empowerment** of women within the household, (iv) the **land holdings** of the family, and (v) the presence of **toddlers** in the household. Length of membership is intended to measure a general effect of access to microfinance and, in particular, income effects derived from membership. The internal account measures risk-management effects. Women empowerment measures gender effects (*e.g.* the importance of women in the decision-making process for the *ith* child's education). Land holdings and the presence of toddlers measure the child-labor demand effect. Landholdings are a proxy for physical wealth and also reflect the potential demand for farm labor within the household. A description of these variables comes next, while the sources of data are discussed in the following section.

- **Length of membership.** For the Batallas clients, the survey was designed in order to compare new clients (with less than one year of membership) with old clients (with more than two years). This differentiation was used in the regression analysis by incorporating a dummy variable that takes the value of one for old clients and zero for new clients. For the other datasets, the variable to measure exposure to microfinance was the computed number of months that the earliest client in the household had been a member of the

organization. A dummy analog to the one used in the Batallas dataset was computed for all the samples as well.

- **Internal account.** This variable is a dummy that takes the value of one when the client declared having used the internal account during the year previous to the survey. The expected sign is negative, assuming the risk-management effect exists, so the internal account prevents households from taking children out of school, when they are confronted by shocks.
- **Women empowerment.** This variable represents the proportion of the accumulated human capital –measured by the number of years of schooling– held by the women who work in each household. The expected sign is negative, to incorporate the view that empowerment reduces the schooling gap. There were some doubts about possible correlation of this variable with the household’s human capital variable, but the relationship was weak and both can be used without fear of collinearity effects.
- **Land holdings or own arable lands.** This variable shows the size of the plots of land owned by the household and used for crops and other productive activities, measured in hectares. The sign will be positive if, when the household owns land, it is likely that it will demand the child’s labor time for farming activities, in competition with school time. The sign may be negative, however, if the variable influences education through the level of the household’s wealth and its availability as a consumption-smoothing tool.

- **Presence of toddlers.** This is a dummy variable that takes the value of one if the household of the child has at least one member six years old or younger. The expected sign is positive, under the hypothesis that the presence of toddlers requires that some children be kept out of school to take care of them, specially if the parents are engaged in income-generating activities, possibly funded by the loan.

Regional variables. These variables capture if the household is located in an **urban** or a **rural** municipality. In the case of the CRECER dataset, the urban setting can be differentiated between capital towns of municipalities and other urban municipalities. These variables are proxies both for the quality of education and job opportunities, which increase the marginal rate of return from education. They are constructed as explained next:

- **Rurality of the household.** This variable considers the difference between a household living in the rural areas, the urban areas, and capital towns of municipalities. It is constructed through dummy variables. Capital towns is the variable dropped for the econometric analysis for the CRECER dataset. The rural dummy can be expected to be positive compared to the control (capital towns) if the hypothesis is that the rural areas are less likely to have schools with good quality of education and attractive job opportunities for educated people.

3.6. The Data

The data for the empirical analysis are obtained from Bolivia, one of the poorest countries in Latin America. Deep inequalities and poor quality characterize its education outcomes. For instance, the average number of years of schooling completed declined from 4.2 in 1960 to 4.0 in 1980 and then increased to 5.5 in 2000 (Barro and Jong-Wha, 2000). Productivity and wages are very low for a large share of the working population. Over 45 percent of urban male workers earn less than one dollar a day (Duryea and Pagés, 2002).

In turn, over the past 15 years, Bolivia has experienced a strong development of microfinance (González-Vega and Rodríguez-Meza, 2002; González-Vega and Villafani-Ibarnegaray, 2004). MFOs, originally developed as employment-generation tools for excluded sectors of society, have grown into a competitive and sustainable segment of the Bolivian financial system. Outreach toward the rural areas is, however, limited compared to urban centers.

The available dataset is made up of the results of three independent household surveys. One survey investigated households of microfinance clients of CRECER and SARTAWI in the municipality of Batallas (from now onwards, referred to as the Batallas dataset). This dataset includes 130 households, mainly from the countryside of the municipality, surveyed in April 2001 (Romero, 2002).

The second dataset resulted from a survey of households of CRECER clients in five departments (Chuquisaca, Cochabamba, La Paz, Oruro, and Potosi) undertaken in

November 2000 (from now onwards referred to as the CRECER dataset). This dataset includes 427 households and about half of the sample comes from rural areas.

The third dataset includes the results of a survey of households of Pro Mujer clients in four departments (Chuquisaca, Cochabamba, La Paz, and Tarija). This survey was conducted in April 2001, and it included 400 households, mostly from urban settings. This dataset will be referred to as the Pro Mujer dataset.

Although the three surveys were designed for different purposes, they share the same structure, given the OSU connection. A large number of the same questions were asked in all three cases.

For the analysis of education achievements, the children in school age (7 to 18 years old) were divided into two groups: primary-school children (7 to 12 years old) and high-school children (13 to 18 years old). Tests with the sub-sample of children between 7 and 12 years old, a fairly homogeneous group, did not reveal any key significant differences according to participation. This paper focuses, therefore, on the sub-sample of children from 13 to 18 years old.

The results for the dependent variable, the education gap, are reported in Table 3.1. On average, 64 percent of all children in secondary-school age show some schooling gap. Most of the gap cases correspond to one or two years of delay (37 percent), with a few cases of complete abandonment of studies. Comparing among datasets, the CRECER sample is the one with the smallest share of children without a gap. This may reflect deficits from the supply side, as half of the CRECER sample comes from rural settings where schools are less available. Although the Batallas population is mostly rural,

the road network and school facilities are more frequent there, due to its closeness to La Paz.

Main statistics for the independent variables in the sub-sample of children in high school age (13 to 18 years old) are presented in Table 3.2.

Schooling Gap (years)	Survey			Total
	Batallas	CRECER	Pro Mujer	
0	62 (46)	103 (29)	144 (40)	309 (36)
1	28 (21)	103 (29)	84 (23)	215 (25)
2	13 (10)	49 (14)	42 (12)	104 (12)
3	7 (5)	29 (8)	28 (8)	64 (8)
4	4 (3)	15 (4)	19 (5)	38 (4)
5	6 (4)	10 (3)	9 (2)	25 (3)
6 and more	15 (11)	46 (13)	37 (10)	98 (11)

Source: client household surveys

Table 3.1. Schooling gap for the sample of children 13-18 years old. (Percentages in parenthesis)

Variable	BATALLAS	CRECER	Pro Mujer	Total
Observations (number)	135	355	363	853
Average schooling gap (years)	1.8	2.2	1.8	1.9
Average age (years)	15.3	15.4	15.4	15.4
Household size (members)	6.8	6.7	7.1	6.9
Students in the household (number)	3.6	3.4	3.7	3.6
Children in the household (number)	4.1	3.9	4.1	4.0
Presence of toddlers (percent)	47	40	53	47
Direct son/daughter (percent)	N/A	91	87	N/A
Distance to school (minutes)	30	17	11	17
Proportion living in urban municipalities (percent)	0	49	100	65
Proportion living in rural municipalities (percent)	100	51	0	35
Human capital of family workers (years of schooling)	28	20	35	28
Average holdings of land (hectares)	1.4	1.8	2.1	1.9
Basic needs satisfaction index	0.62	0.75	0.79	0.75
Adjusted BNSI	0.76	0.85	0.89	0.85
Human capital of working women as a fraction of total (percent)	43	46	48	47
Average human capital of female workers (years)	6	13	8	10
Human capital of women as a fraction of the household's (percent)	42	51	47	48
Proportion of income generated by women (percent)	53	56	53	54
Participation of women on education decisions (percent)	85	N/A	N/A	N/A
Affiliation to the MFO (years)	4.8	2.0	2.8	2.8
Affiliation to the MFO (months)	N/A	18	N/A	N/A
Proportion of old clients (percent)	31	35	68	49
Knowledge about internal account (percent)	N/A	94	58	76
Use of internal account (percent)	N/A	55	16	37

N/A means not available

Table 3.2. Main statistics for the sub-sample of high school children (13-18 years old)

3.7. Results

The regression analysis examines the dependence of the schooling gap on the explanatory variables. The regressions test for the difference in gaps between households that have had access to credit for a certain period of time versus households with members with less experience in the program. The hypothesis is that access to credit makes a marginal difference in the size of the gap. The results are shown in Table 3.3. Regressions are calculated for the three samples separately.

For all the cases, the independent variable for length of access to credit is a dummy taking the value of one for old clients and zero for new clients.

In the Batallas and CRECER cases, the coefficient for the *membership* as client of the microfinance program variable is negative and statistically significant. The null hypothesis can thus be rejected. It appears that, *ceteris paribus*, children from households with a longer history of affiliation to microfinance programs have a greater chance of being kept longer in school in contrast to children from households just entering the program. This is the central and an important result.

Variable	Batallas	CRECER	Pro Mujer
	Coeff.	Coeff.	Coeff.
Length of membership	-0.74***	-0.21*	0.11
Child's age	0.19**	0.12***	0.14***
Child's gender	0.04		-0.08
Position of child		0.17***	
Child working			-0.46**
HH human capital	-0.13**	-0.09***	-0.26***
Poverty index	-0.92*	0.22	-0.76**
Land holdings	0.10*	0.01	-0.00
Internal account		-0.20*	0.35*
Empowerment	-0.07*	-0.03***	-0.77**
Rural dummy		0.03	
Constant	-0.60	-0.55	1.27*
Overdispersion	1.16***	0.65***	0.60***
Number of observations	134	343	296
LR chi2(k)	28.97	77.92	109.78
Prob > chi2	0.00	0.00	0.00
Pseudo R2	0.06	0.06	0.10

(*) Significant at 10% (**) Significant at 5% (***) Significant at 1%

Table 3.3. Results from regressions about schooling.

For the case of Pro Mujer, however, the membership variable is not significant. This result may be explained by the fact that households from the Pro Mujer survey are mainly urban and engaged in microenterprise activities. Therefore, the opportunity cost of education is higher, as the creation of these microenterprises may demand child labor, either to work in the new activity or to fulfill the duties that now the parents are unable

to complete due to their commitment to the microenterprise. This finding suggests a dilemma for urban microfinance.

As expected, the coefficient for the variable *age* is significant and positive. That is, the older the child, the greater the probability that she/he will show an education gap.

The coefficient for the variable *gender* is positive although not significant. This is an important result. Lack of statistical significance means that there are no differences between girls and boys in their educational achievements. The results cannot show if this gender neutrality has been due to the influence of the MFO or not, but anecdotal references to this effect abound. Gender is not included in the CRECER regression due to the presence of collinearity with the empowerment variables. That is, households with high women empowerment are highly correlated to girls' school attendance.

In order to consider intrahousehold characteristics, the presence of *toddlers* in the family was tested for. This attribute causes a direct effect (positive sign) on the educational delays of children. This effect, however, is not significant and the variable was not included in the final regressions. In the CRECER dataset it was possible to build a variable showing the *position* of the child compared to her/his siblings. The regression results show a positive and statistically significant effect on the schooling gap, which supports the hypothesis that position matters and that first daughters/sons are more likely to be sent to school than younger siblings.

The *distance to school* is not significant in any case. This may show that lags in educational performance can be attributed more to demand factors than to supply factors such as the existence of schools. This variable was dropped from the final regressions.

The household's *human capital* (the average level of education of the working members) significantly reduces the schooling gap. More educated household decision-makers have a greater propensity to encourage the education of their children. This may be facilitated by the higher incomes earned by more educated household workers. A poverty trap related to human capital formation may therefore exist.

The coefficient on agricultural *land* holdings is positive in the Batallas and CRECER cases but significant only in the case of the Batallas dataset. This finding may be explained by the fact that Batallas is an agricultural region and that the dataset is the one with the highest proportion of rural households. For them, agricultural activities play a decisive role in their income-generation decisions. In this case, farming appears to be a substitute or a competition for education. This presents policymakers with a similar paradoxical result: increased opportunities to farm may pull children away from school. To the extent to which farming households tend to be the poorest, this may create a poverty trap for these households. For the case of Pro Mujer, this effect is negative although not significant. This confirms the hypothesis that access to land generates an opportunity cost of education for agricultural households. This finding is in contrast to that in Trigueros (2002), who finds that land ownership in El Salvador explains continued enrollment in the presence of adverse shocks.

The lack of significance of the explanatory variable of *length of membership* in the Pro Mujer dataset leads to the suspicion that the opportunity costs of education in urban settings are higher than in rural settings. To confirm this presumption, a new variable was included in the Pro Mujer regression; a dummy variable with value of one

if the child is working either in family productive activities or in off house employment. This variable was significant and showed the expected negative sign: given the broader spectrum of labor opportunities in urban settings (compared to rural ones), children engage in income-generating opportunities more frequently, with the corresponding delay in or withdrawal from school. It was not possible to establish with accuracy if this is an effect of access to microfinance, which enhances productive opportunities within the household, or of the differential in the labor market characteristics between rural and urban scenarios.

The coefficient for the *poverty* index is significant and shows the expected sign. That is, households with the least satisfaction of basic needs have children with greater schooling gaps. This reflects the high opportunity cost of the child's school attendance in households with a low productivity of labor and a tight budget constraint. In the absence of other productive household assets, expected returns from education also appear low. A poverty trap may also exist here.

The *internal account* variable was available only for the CRECER and Pro Mujer datasets, and it showed ambiguous results. In the case of the CRECER dataset – where the internal account is widely used– the coefficient was negative and significant, confirming the effect of access to microfinance as a tool useful in consumption smoothing and risk coping, and therefore improving the human capital formation of the borrowers' children. In the case of the Pro Mujer dataset –where the internal account use was reported only in 16 percent of the households– the coefficient was significant but positive. This result may confirm the fact that Pro Mujer clients use microfinance in

general and the internal account in particular to increase income generating opportunities, increasing in turn the demand for child labor, which results in larger schooling gaps for children.

The *empowerment* variable always shows a negative and statistically significant coefficient. This indicates that the empowerment of women reduces the education gap for high-school children. This is an important result, confirming the importance of women in overcoming poverty at household level across generations (gender effect).

The dummy variables used to control for the type of household (rural or urban) are not significant. They are necessary, however, to provide consistency to the regression and to account for differences among types of household. For instance, if they are dropped from the regression, the coefficient related to landholdings becomes not significant, as landholdings have a different impact in rural than in urban households. For rural households, landholdings are a factor of production, which generate demands for the household members' labor, while for urban households land ownership mostly reflects wealth. Demands for child labor may still emerge in urban households if the children are asked to help in the microenterprise activities or help with childcare.

Over-dispersion was observed in all regressions, leading to the conclusion that the negative binomial regression model was the appropriate choice. With this method, over-acceptance of coefficient significance and over-rejection of the null hypothesis is avoided.

3.7.1. Marginal Effects and Elasticities

Given the econometric specification adopted, the coefficients that result from a negative binomial regression are only useful for their sign and significance but not for their magnitude. This is because the functional form is not linear but exponential, and the derivative of the function with respect to any independent variable is not the coefficient but the product of the coefficient and the mean function, evaluated at specified values for all the independent variables. A proper assessment of the effects of different variables can, therefore, be achieved only by looking at the marginal effects, which measure the actual impact of changes in each independent variable over the dependent variable, *ceteris paribus* (Table 3.4).

Here, the marginal effects are calculated at both the mean and the median values of the independent variables. Moreover, to assess the relative responsiveness of the dependent variable and to compare across independent variables, it is necessary to compute elasticities, which consider not absolute but relative changes in magnitude. Elasticities tell how proportional increases in the independent variable affect (also in percentage terms) the dependent variable. These elasticities are shown in Table 3.5, and they are also calculated at the mean and median values of the independent variables. Both marginal effects and elasticities are discussed for each one of the surveys.

For the case of Batallas, participation in a microfinance program has important effects on schooling, as measured by the length of membership (that is, by the difference between new and old clients). In effect, old clients have, on average and controlling for other things, children with almost one year less of educational gap compared to new

clients. The impact of the package of microfinance services from these organizations is beneficial, significant and, most importantly, substantial, both for the average and median household. The empowerment of women and the education of household members of working age are also beneficial and significant. One extra year of schooling of household members, however, reduces the gap by about one-fifth of a year. A smaller effect, but still significant, is attributed to the level of education of the females in the household labor force, which is the proxy used for empowerment. Less poor households show, on average, significantly smaller gaps. Finally, an additional hectare of land increases the demand for child labor, and it increases the gap by about one-sixth of a year.

Still for the case of Batallas, the elasticity of the schooling gap of children with respect to membership is, however, lower than the elasticities corresponding to variables such as the household's human capital, the poverty index, and empowerment. That is, schooling is very responsive to reductions in poverty and to the gender effect and information effects.

In particular, a 10-percent improvement in the poverty index induces a 7-percent reduction in the schooling gap. Similarly, a 10-percent increase in the average schooling of the working members of the household induces a 7.6 percent reduction in the gap. Regarding female workers in the household, the reduction in the gap would be 4.3 percent in response to a 10-percent increase in their schooling, *ceteris paribus*. The high elasticity of the gap with respect to age shows that older children are more likely to have less schooling than expected for their age and that this occurs at an increasing rate.

Variable	Batallas		CRECER		Pro Mujer	
	At mean	At median	At mean	At median	At mean	At median
Membership	-0.91***	-0.77***	-0.39*	-0.35*	0.15	0.12
Age of child	0.26**	0.28**	0.21***	0.18***	0.19***	0.17***
Gender of child	0.06	0.07			-0.04	-0.10
Position			0.31***	0.25***		
Child working					-0.71**	-0.71**
HH human capital	-0.18**	-0.19**	-0.17***	-0.14***	-0.35***	-0.31***
Poverty Index	-1.26*	-1.36	0.41	0.34	-1.03**	-0.92**
Land holdings	0.14*	0.15*	0.01	0.01	-0.00	-0.00
Internal account			-0.37	-0.34*	0.53	0.50
Empowerment	-0.09*	-0.10*	-0.06***	-0.05***	-1.04**	-0.93**
Rural dummy			0.05	0.04		

(*) Significant at 10% (**) Significant at 5% (***) Significant at 1%

Table 3.4. Marginal effects of the schooling gap for the variables used in the regression, calculated at the mean and median values of the variables.

Variable	Batallas		CRECER		Pro Mujer	
	At mean	At median	At mean	At median	At mean	At median
Membership	-0.23***	N/A	-0.12*	-0.21*	0.06	0.11
Age	2.89**	2.83**	1.80***	1.75***	2.18***	2.13***
Gender	0.02	N/A			-0.04	-0.04
Position			0.39***	-0.33***		
Child working					-0.35**	-0.46***
HH human capital	-0.76**	-0.76**	-0.59***	-0.56***	-1.77***	-1.73***
Poverty Index	-0.70*	-0.70*	0.19	0.19	-0.68**	-0.69**
Land holdings	0.13*	0.05*	0.02	0.00	-0.01	N/A
Internal account			-0.11	-0.20*	0.06*	N/A
Empowerment	-0.43*	-0.41*	-0.44***	-0.36***	-0.41**	-0.39**
Rural dummy			0.01	0.03		

(*) Significant at 10% (**) Significant at 5% (***) Significant at 1%

Table 3.5. Elasticities of the schooling gap with respect to the variables used in the regression, calculated at the mean and the median values of the variables.

The results for the CRECER sample are similar, but some special features are worth mentioning. In absolute terms, the length of membership in the program (new versus old clients) continues to be beneficial, significant and still substantial, although not as much as in the case of Batallas, where CRECER is also one of two organizations examined. This is an interesting result, among other things because Batallas is one of the earlier locations for CRECER, while the broader sample includes other regions of the country where program development has been more recent. Use of the internal account (which is a proxy for the risk-management effect) has the correct sign and has a statistically significant marginal effect in reducing the schooling gap when measured for median values but not when measured for average values of the variables.

The position of the child with respect to her/his siblings matters; that is, a particular child has, on average, almost a third of a year more of schooling gap compared to his/her immediately next older sibling, when compared at the same age. The beneficial effect of the household's human capital on the education of children is slightly smaller than for the Batallas sample. The same is true for empowerment, but the effects have a stronger statistical significance.

When looking at the elasticities, similar results as in the Batallas data set emerge. The schooling gap is more elastic to the household's human capital and to the empowerment of women than to other variables. The elasticity of the gap with respect to the empowerment of women is similar to the observed in Batallas, while the elasticities of the gap with respect to program participation and household human capital are lower for the larger CRECER sample than for Batallas.

Finally, results for the Pro Mujer data set may reflect consequences of living in an urban setting. The marginal effects of membership are no longer significant. Instead, empowerment of women, household human capital, and the poverty index have strong significant marginal effects. The elasticity of the schooling gap is quite high with respect to poverty. Women in urban settings are in charge of their productive activities –mainly in trade– through microenterprises. These women gain empowerment from both their earnings and access to microfinance. Empowerment and human capital matter a lot in this setting, but the influence of program participation is not properly captured by the specification. Moreover, greater job opportunities for children seem to reduce significantly the schooling gap, which is another perplexing result.

Across data sets, the results are consistent, especially for the impact of empowerment of women and the household's human capital on the children's educational performance. This finding highlights the outcome of the strategy of offering financial services to women.

3.8. Conclusions

Poverty in Bolivia is dramatic, reducing standards of living not only for the current but also for the future generation. In the long run, the alleviation of poverty will require substantial improvements in education. To make this possible, constraints on the supply as well as the demand side of education must be overcome. The demand side of the education equation seems to be influenced by the attitudes, opportunities, and constraints of poor rural households. The results of this dissertation confirm this

perspective. If a clear diagnosis is a precondition for the adoption of appropriate policies, important lessons emerge from this essay. These results suggest that programs that improve the income-generating capacity of households and their ability to withstand adverse shocks shift the demand for education. In particular, the beneficial role of the internal account, though improvement in risk management, highlights the comparative advantage of village banking programs that emphasize this service.

Consistent with the threat of a poverty trap, deeper levels of poverty are associated with lower demands for education. The results for the index of basic needs satisfaction in all cases confirm a significant and unfavorable influence of poverty on schooling gaps. Educated household workers generate a stronger demand for the education of household children than non-educated members do. Larger stocks of human capital are not only associated with higher household incomes but also with more optimistic perceptions about the returns from education. These outcomes reinforce the prediction of a poverty trap: less educated parents demand less education for their children. Non-formal adult education may in part offset these attitudes.

The relationship between wealth and the demand for education may create, however, some policy dilemmas. First, greater access to land and, therefore, to opportunities for farming appear to increase the household's demand for child labor. Land tenure policies, therefore, while increasing income opportunities for the household may, at the same time, increase the opportunity cost of keeping children at school. Similar effects seem to emerge from the encouragement of household microenterprises.

Larger stocks of capital or land make these households search for additional labor inputs, given the highly labor-intensive technologies they use. The first source to fill this demand for labor is the family, thereby creating a trade-off between potential future welfare and the satisfaction of current needs. Even when household members are aware of some advantages from educating their children, their precarious conditions may force them to sacrifice the potential flow of future benefits in order to compensate for extremely low current income flows. If, further, there is the perception that current employment options do not reward sufficiently investments in education, the best alternative is to keep children employed at the farm or microenterprise since their early ages.

Unfortunately, at low levels of household income, this adverse impact of incentives to agricultural production and microenterprise development on the demand for education will be inevitable. Agricultural intensification policies, rather than land extensification, which substantially increase the productivity of available household labor and other resources and improve the returns on human capital, may be the only way out of this dilemma. There is a coincidence here with the favorable impacts of intensification on natural resource conservation, as shown in the first essay.

Another challenge presented by this dilemma is the demand of youth labor for childcare. As the nascent microenterprise demands the attention of the older women in the household, an internal demand for childcare emerges, and this demand will be met by keeping the older children at home and away from school. This effect will be stronger in younger families, because of the larger number of toddlers and the smaller

number of adults in the household. The education component of some microfinance programs may have an impact on the spacing of pregnancies and on the fertility rates of these women, and this may contribute to a reduction of this paradoxical threat to human capital formation (Romero, 2002).

The importance of access to credit and other financial services that allow households to postpone or smooth their consumption, in increasing their investment in education, leads to evident policy recommendations. Microfinance organizations in Bolivia have been able to reach segments of the rural population that otherwise would not have had access to these services and, to the extent to which they have been cost-effective, this has been a valuable development contribution. The sustainability and cost-effectiveness of these MFOs has not been evaluated, however, in this dissertation.

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