CAN A CREDIT-INSURANCE PACKAGE INCREASE THE ADOPTION OF A MODERN VARIETY PACKAGE?: AN APPLICATION TO HONDURAN DRY BEAN FARMERS

By

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ABSTRACT

CAN A CREDIT-INSURANCE PACKAGE INCREASE THE ADOPTION OF A MODERN VARIETY PACKAGE?: AN APPLICATION TO HONDURAN DRY BEAN FARMERS

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As farmers face an expected income-risk tradeoff, they can only obtain a higher expected income by increasing their exposure to risk. Many farmers choose low-yielding technologies (e.g., traditional varieties) with lower yield variability over high-yielding technologies (e.g., modern varieties) with higher yield variability. Farmers' lack of liquidity at planting time exacerbates the income-risk tradeoff by raising the cost of investing in modern varieties--hence, making yield uncertainty even more daunting.

The objective of this study is to assess the potential of a credit-insurance package to increase farmer adoption of modern bean varieties and complementary inputs (e.g., fertilizer) and thereby increase bean farmers' gross income in Honduras. The specific objectives are to: 1) assess if the change from a traditional variety to a modern variety is profitable, and if the change from a traditional variety package to a modern variety package is profitable, 2) assess farmers' exposure to price risk, perceived yield risk, and consumption risk, 3) identify how farmers currently cope with shocks, 4) evaluate the existing insurance policies for bean farms adopting modern varieties to observe the extent of risk transfer and load in excess of the actuarial fair rate, and propose alternative policies that improve risk transfer, and 5) assess the benefits of a credit-insurance package for bean farmers in Honduras.

The change from a traditional variety package to a modern variety package is profitable as it is shown with partial budgets together with the marginal income from fertilizer compared to its marginal cost. However, farmers face price risk at a level of approximately 20% coefficient

of variation (CV) for both beans and corn, and a yield risk at a range of approximately 32%-34% CV for beans depending on the bean technology, and 32% CV for corn.

Currently farmers in Honduras are offered catastrophic crop insurance policies (i.e., coverages of 45%) with high loads to the premium (i.e., 3-5) that do not provide high levels of risk transfer, although it provides the means to grow another crop in case of a peril striking. Thus, farmers decide to mainly cope with shocks by working in another job besides their crop enterprise (50%), selling their assets (24%), and asking for a loan from friends, family or other person (14%).

Simulations, using a multiperiod stochastic model where households maximize expected consumption utility, were used to evaluate farmers' decisions on obtaining credit and purchasing crop insurance. Farmers' elicited probability distributions together with secondary data and expert opinion were used for specifying the stochastic element in the simulation.

Farmers under general conditions would be benefited by a subsidized credit-insurance package (i.e., load of 1.0) that enables them to change from a traditional variety package (i.e., low fertilizer and traditional seed) to a modern variety package (i.e., high fertilizer level and modern seed). The specific conditions in which insurance would benefit are when farmers are highly risk averse and do not need credit for crop production and living in villages with relatively high prices, or, moderately risk averse farmers that need credit in villages with relatively high prices. It is advisable to revisit the approach of estimating the yield probability distributions due to the problems encountered.

I would like to dedicate this dissertation to my mother, Ilma, who has always encouraged me to pursue great things in life.

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KEY TO SYMBOLS OR ABBREVIATIONS

BAC	Central American Bank
BANADESA	Honduran National Agrarian Development Bank
CEPAL	Economic Commission for Latin America and the Caribbean
CDF	Cumulative Density Function
CE	Certainty Equivalent
CER	Certainty Equivalent Ratio
CV	Coefficient of variation
FAO	Food and Agriculture Organization of the United Nations
FDSD	First Degree Stochastic Dominance
HSBC	Hong Kong Shanghai Bank Corporation in Honduras
ICCYA	Investment Cost Coverage with Yield Adjustment
INE	Honduran National Statistics Institute
IS	Insurance Superintendence
ODEF	Feminine Entrepreneurial Development Organization
PCGI	Percentage Chance of Going Insolvent
ProAgro	Agrarian Protection Insurance Company in Honduras
SBI	Superintendence of banks and Insurance
SDSD	Second Degree Stochastic Dominance
SIMPAH	Honduran Agricultural Product Information System
SPVWUM	Stochastic Present Value of Wealth Utility Model
YIPCA	Yield Insurance with Production Cost Adjustment

1. CHAPTER I: Introduction

1.1. Problem Statement

Small-scale farmers in Honduras, with a significant share of land dedicated to dry bean production, are thought to be constrained from adopting a modern variety package by cash-flow and risk constraints (Smeltekop, 2005). Smeltekop reported that farmers stated that they do not want to risk a low yield with modern varieties in a given year due to terminal drought, the factor farmers expressed to be more constraining to increase yields. Thus, farmers face an income-risk tradeoff-- they can only obtain a higher expected income by increasing their exposure to risk. As a result, they choose traditional varieties with lower yield variability over modern varieties with higher yield variability. This income-risk tradeoff is exacerbated by farmers' lack of liquidity at planting time, which raises the cost of investing in modern varieties and hence makes yield uncertainty even more daunting. In contrast, experts in Honduras suggest this perception is due to farmers' experience planting older improved varieties compared to the newly released varieties (Rosas, 2009; personal communication). Still, the potential liquidity constraint remains. Consequently, farmers potentially are in the 'poverty trap'.

Crop yield insurance potentially increases farmers' choices by transferring at least some risk to the insurer (Ray, 1981). Access to credit allows capital-constrained farmers to acquire cash to purchase modern varieties and complementary inputs prior to planting. Crop insurance reduces risk and increases the farmers' willingness to purchase modern varieties and complementary inputs for risk averse farmers. Thus, a successful credit-insurance package is hypothesized to increase farmers' incomes through the purchase of modern varieties and complementary inputs (i.e., modern variety package) in three out of four cases from a full factorial combination of the two factors, (i.e., risk aversion and capital-constraint) with two levels within each factor (i.e., capital constrained or not capital constrained; risk averse or not risk averse). The three relevant cases from the full factorial combination of these two factors are the following: 1) farmers not constrained by capital but who are driven by risk aversion to purchase traditional varieties instead of modern varieties because of failure of the latter in drought situations, 2) farmers constrained by capital and driven by risk aversion to not access credit to purchase a modern variety and complementary inputs in case of a bad event happening and not being able to repay the loan, and 3) farmers who are constrained by capital and not risk averse, would be required by banks to purchase crop insurance to be able to acquire the loan to buy the modern variety package[1]. This study will look at the two cases of risk aversion (i.e., first two cases) within those three relevant cases.

In these scenarios, credit demand is directly assumed for the capital constrained farmers as opposed to derived from financial statements as is practiced in other studies. Whether or not credit-insurance packages are successful depends on socioeconomic conditions.

This study is motivated by the need to increase farmers' expected gross income, the low participation of crop insurance in Honduras, and the potential ability of crop insurance to increase bean farmers' gross income by facilitating the adoption of modern varieties.

1.2. Objectives

The objective of this study is to assess the potential of a credit-insurance package to increase farmer adoption of modern bean varieties and complementary inputs (e.g., fertilizer) in

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[1] The fourth scenario consists of a farmer not constrained by capital and not risk averse, which is not relevant since she would obtain the modern variety package if it outperforms the traditional variety as it is portrayed in this study.

order to increase bean farmers' gross income[2] in Honduras. The specific objectives are to: 1) assess if the change from a traditional variety to a modern variety is profitable, and if the change from a traditional variety package to a modern variety package is profitable, 2) assess farmers' exposure to price risk, perceived yield risk, and consumption risk, 3) identify how farmers currently cope with shocks, 4) evaluate the existing insurance policies for bean farms adopting modern varieties to observe the extent of risk transfer and load in excess of the actuarial fair rate, and propose alternative policies that improve risk transfer, and 5) assess the benefits of a credit-insurance package for bean farmers in Honduras.

1.3. Contribution

The research will contribute to our understanding of the limitations farmers face in adopting a modern bean variety package and provide insights regarding farmers' incentives of adopting or not adopting improved bean technologies. If the hypothesis that modern varieties are perceived to increase risk is correct, this study will contribute to identifying institutional adjustments (e.g., changes in insurance coverages) necessary to increase adoption. This research will also contribute to the empirical work on crop insurance in developing countries. More specifically, it will inform insurance companies about farmers' reactions to incentives or disincentives to purchasing crop insurance.

1.4. Dissertation Outline

Chapter 2 presents a review of the theory, concepts, and empirical work used as the foundation of the study. The study, which develops a multiperiod stochastic simulation model to capture the impact of stochastic yields and prices, uses the expected utility framework,

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[2] Gross income is defined in this study as revenue minus variable costs, except for family labor.

insolvency metrics, risk management, and portfolio theory concepts. This chapter presents concepts of risk management, crop insurance, and credit to provide insight to farmer modern bean variety adoption.

Chapter 3 develops the framework of the multiperiod stochastic simulation model used, from its expected utility model to the specific structure and parameters of the simulation model used. It includes the variables, parameters and correlation matrix that need to be collected and/or established to estimate the model metrics (e.g., certainty equivalent, expected utility). It presents the sources of information (i.e., key informant interviews, farmer survey, and secondary information) and procedures followed for data collection (e.g., sampling procedure for the survey). It also presents technology comparisons, which are used to answer the question of the suitability of the use of crop insurance and credit to enhance modern bean variety adoption. Finally, it discusses the elicitation of farmer subjective yield probability distribution functions for use as a source of randomness in the simulation model, as well as to obtain the farmers' view of their perceived risk.

Chapter 4 presents estimates of the basic statistics and distribution of the variables, establishes the parameters, and correlation values for the correlation matrix to be used in the simulation model. It describes the general policies and parameters of credit and crop insurance contracts used by banks and insurance companies. The chapter describes problems that emerged from the farmer yield distribution elicitation and the steps followed to overcome those problems and obtain subjective crop yield probability density distributions. It also indicates parameters that were estimated from data obtained from the farmer survey and used in the simulation model regarding bean and corn costs, farmer assets, farmers' off-farm income, etc. Finally, it presents differences between types of crop insurance contracts and differences between policies within the same type of insurance contract.

Chapter 5 presents the results and analysis of the application of the simulation model to provide insight into the objective of assessing the benefit of a credit-insurance package. Comparisons between technology categories are presented and discussed.

Chapter 6 presents the study's conclusion, policy recommendations, limitations, and recommendations for future research. It discusses possible problem mitigation techniques for future researchers when eliciting farmers' yield distributions.

2. CHAPTER II: Literature Review

This chapter reviews the literature on Honduran socioeconomic characteristics, consumption smoothing, risk management, crop insurance, credit, and simulation as a tool for generating and understanding of decision making.

The Honduran socioeconomic characteristics section provides a sense of the possible demand and impact of introducing a credit-insurance package by documenting the levels of poverty. It also provides some general background information of farmers' research on the yield differentials between traditional and modern varieties. Additionally, this section discusses the establishment of crop insurance in Honduras and the firms offering insurance.

The consumption smoothing section discusses farmers' balance of their spending and saving, but where risk and credit constraints are present, farmers might make production choices (i.e., plant traditional varieties) that result in suboptimal consumption levels.

The risk management strategies, together with the crop insurance and credit sections, present the options farmers have to manage risk and how these complement each other; thereby enabling farmers to make higher yielding production choices (i.e., grow modern varieties) and move to a higher level of consumption smoothing, higher expected utility, and higher income.

The evaluating risk section presents a way to evaluate farmers' choices (i.e., type of variety to grow) within a context of risk exposure. It presents why a stochastic present value of wealth utility model (SPVWUM)--derived from simulated outcomes in multiperiod scenarios with quasi-permanent choices—is appropriate for evaluating the choice of varieties. Certainty equivalent is the metric of comparison between choices. Additionally, the chapter includes a description of other ways of evaluating decisions under risk. More specifically, it discusses the use of dynamic programming within an income-consumption model, and also the use of stochastic dominance as a criterion to evaluate choices.

The section discusses factors affecting adoption and briefly describes why a credit-insurance package could increase adoption of modern varieties and increase farmers' expected gross income.

Finally, the simulation section describes why simulation is a good approach to emulate the farmer decision-making process and identifies studies that have used Excel add in @Risk for simulation.

2.1. Honduran socioeconomic characteristics

2.1.1. Poverty in Honduras and the use of crop insurance in developing countries

According to the Grameen Foundation (2007), more than 66 percent of Honduras' population lives below the poverty line of $2 a day and in rural areas and 61 percent of families live below $1 a day. The Statistics National Institute in Honduras (INE) in (2010) reported 34% of the rural population lives below $1 a day. The 2012 Honduran population was 8,385,072. The rural population was 4,004,162 (INE, 2012). This provides an idea of how great an impact an efficient credit-insurance package could have on poor households in rural areas. It also provides a sense of the potential demand for credit-insurance package.

Various studies have found that the adoption of modern bean varieties increases farmers' income. However, some experts have noted that due to the modern varieties longer maturation period, compared to the traditional varieties (i.e., 10 day difference), modern varieties have a higher yield variance--which increases farmers' income variance (Smeltekop, 2005) because of weather exposure. Crop yield insurance potentially reduces the downside risk which in turn reduces income variance, and at the same time encouraging the use of modern varieties to increase farmers' income. Many efforts are currently in place to introduce crop insurance into developing countries. Most of these efforts focus on introducing weather index insurance.

2.1.2. Characteristics of dry bean farmers in Honduras

While this study of a credit-insurance package focuses on bean farmers with a significant portion of land devoted to dry beans, a significant proportion of the bean farmers in Honduras also grow corn. Approximately 300,000 families in Honduras grow both bean and corn (IICA, 2009). Thus, general background information of these two crops sets the stage for showing how the credit-insurance package would need to work under those conditions.

2.1.2.1. Dry beans and corn yields

In Honduras, staple crops are grown during two seasons—the *Primera* (May to mid-August) and the *Postrera* (mid-August to December). National corn yields for the *Primera* and *Postrera* (i.e., from 1986 to 1999) averaged 1,573 kg/ha and 1,395 kg/ha, respectively. Bean yields for the *Primera* and *Postrera* (i.e., from 1986 to 1999) averaged 632 kg/ha and 702 kg/ha, respectively (INE, 2006).

In 2002, 72 bean farmers were surveyed in El Paraiso and Olancho departments. These two departments were chosen because they have the largest bean area planted (i.e., El Paraiso 13% and Olancho 15%, of the total planted area; SECPLAN, 1994). Eighty six percent and fifty seven percent of these bean farmers grew corn in the *Primera* (2002) and *Postrera* (2001), respectively (Pejuan, 2005).   While, 35% of the bean farmers grew corn in one season, 54% grew it in both seasons, and 11% did not grew corn at all. Farmers in El Paraiso and Olancho planted a similar area to beans in the *Postrera* (2.12 ha and 2.02 ha, respectively), but in the *Primera*, farmers in El Paraiso planted more area to beans than farmers in Olancho (1.37ha and 0.76 ha, respectively) (Table 1).

Table 1. Average area and average of farmers planting corn and bean in Postrera (2001) and Primera (2002), by department, Honduras.

	Average area (ha)				Average of farmers planting crop area (ha)			
	Department				Department			
	El Paraiso		Olancho		El Paraiso		Olancho	
Season	Bean	Corn	Bean	Corn	Bean	Corn	Bean	Corn
Postrera	2.12	1.16	2.02	1.81	2.12	2.45	2.02	2.72
N_1	36	36	36	36	36	17	36	24
Primera	1.37	2.37	0.76	2.93	1.70	2.59	1.04	3.63
N_2	36	36	36	36	29	33	26	29
N = 72 Source: Pejuan farmer survey, 2002.								

Selection bias is a problem in comparing varieties yield differences in Honduras (Mather 2003). Mather (2003) reported that average yields for modern bean varieties tended to be higher than average yields from traditional varieties, although there was no significant difference between the yield of two types of varieties (Table 2). However, this absence of a yield difference is due to selection bias—farmers who planted traditional bean varieties lived primarily in locations where disease (BGMV) pressure was low. However, farmers who planted modern varieties lived primarily in areas where disease pressure was high. Thus, farmers could have used modern varieties either because of lower expected net revenue from planting BGMV-susceptible traditional varieties or because of a low yield from traditional varieties in years of high disease incidence, or both. To correct for selection bias, Mather applied Lee's (1978) two-step procedure to estimate yield differentials between modern and traditional varieties[3]. Mather found the yield gain percentage difference from growing modern varieties if a farmer is located in a disease risk area.

[3] The counterfactual to modern variety yields is defined as what the yields of modern variety growers would be if they had continued growing traditional varieties.

Table 2. Mean yield (kg/ha) of traditional and modern bean varieties, 1999-2000, Honduras.

Type of Variety	***Primera***		***Postrera***	
	1999	**2000**	**1999**	**2000**
Traditional	678	632	615	459
Modern	857	769	667	446
	N = 188	N = 203	N = 242	N = 268
Source: Mather (2002). CRSP/PROFRIJOL Farmer Survey, 2001 (N = 210).				

Smeltekop (2005) asserted that farmers have the misperception that improved varieties always do poorly in drought conditions. This is because based on their limited experience of observing modern varieties perform poorly under drought, farmers generalize to similar but not identical circumstances. Nevertheless, Smeltekop recommended that scientists give priority to developing bean varieties that perform well in drought situations (especially terminal drought) by selecting varieties for early maturity or some other source of drought tolerance.

Pejuan (2005) reported that a larger percentage of the bean area in both El Paraiso (65%) and Olancho (53%) was planted to traditional varieties—which indicates that a significant portion of farmers still plant traditional varieties.

There have been government programs that distribute seed. The World Bank did an ex-ante Poverty and Social Impact Analysis (PSIA) on Technical Production Voucher Program in Honduras and concluded that it had the potential to positively impact the livelihoods of the beneficiaries on the short-term (World Bank, 2010).

With Mather, Smeltekop and Pejuan's findings lead to four questions: 1) what are farmers' perceptions of the probability distributions of yield of modern and traditional varieties? 2) what are the varieties' characteristics that lead to those differences in the distributions, and 3) how important is the early-maturing characteristic for bean varieties? 4) under what conditions does crop insurance motivate farmers to change from traditional varieties to improved varieties?

2.1.3. Insurance schemes in Honduras

Crop insurance was introduced in Honduras at the end of 2001, but by October 2003 policy makers were dissatisfied with the low participation of farmers (Moneda, Oct. 2003). In May 2003, the government proposed a bill requiring farmers who sought credit from government banks to buy crop insurance. This bill was not welcomed by farmer groups, due to the limited area across the country that the insurance companies covered (Moneda, May 2003), and it did not pass as a law. In 2008, compulsive insurance was introduced and later eliminated for individuals seeking credit from the National Development Bank (BANADESA, 2010). Currently, it is strongly suggested.

In November 2003, two private insurance companies began to offer crop insurance–El Ahorro Hondureño and Seguros Atlantida. In 2004, two additional companies--Cooperativos Equidad and Seguros Continental--also began to offer crop insurance (Moneda, Oct. 2003). However, Cooperativos Equidad only provided insurance on a trial basis. Policy makers expressed hope that the entry of these new companies into the insurance market would result in lower premiums and stimulate greater farmer participation (Moneda, Oct 2003).

The two insurance companies with higher market share are Seguros Atlantida and Seguros Ficohsa (which has gained much share from what used to be El Ahorro Hondureño[4]). Both offer similar insurance schemes, but there were a few differences in terms of premiums. At present, these insurance companies insure all perils as a bundle and the premium oscillates around 9-10% of the insured amount (Castillo, 2006). Coverage levels are around 40%[5].

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[4] El Ahorro Hondureño became part of BGA and later purchased by HSBC. HSBC stopped selling crop insurance contracts.

Insurance contracts in these companies have the participation loss[6] (i.e., 30% for drought and 15% for excess rain). The policy's premium ranges from 7.5% to 9.5% of the liability base (liability before adjusting for coverage), depending on the region and the perils that is being insured for.

Sometimes insurance companies offer a collective insurance policy to a group of farmers, each with 1-5 mz (0.7-3.5 ha), but indemnization is paid on an individual basis (i.e., only the farmers who suffered the losses are compensated).

2.2. Consumption Smoothing

Consumption smoothing refers to the idea that farmers will balance their spending and saving to achieve the highest expected utility (Morduch, 1995). When positive shocks to the farmers' income occur, farmers would save. When negative shocks occur, farmers would borrow or use their savings. Crop insurance helps smooth consumption by providing indemnization in the low yielding years.

2.2.1. Income risk tradeoff

The income-risk tradeoff is discussed in the portfolio literature. Sometimes individuals can only achieve a higher expected income by incurring higher risk (e.g., cash crops). It is up to individuals, given their risk preferences, to position themselves on the income-risk frontier and maximize their utility. With complete markets (i.e., ideal market where a complete set of state-contingent claims can be made with existing contracts, and which help smooth consumption) and

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[5] With an indemnity price of beans at L. 8.87/kg; a L. 3,571/ha liability and 1,056 kg/ha yield for a low technology farmer (i.e., as considered by the insurance company) and L. 5,000/ha liability and 1,319 kg/ha yield for a medium technology farmer, highest coverages are around 45% (i.e., 43%).

[6] Participation loss is a term used in the Honduran insurance contracts to refer to the copay.

no credit rationing, the Fisher separation theorem, which asserts that investment decisions to maximize the present value of an enterprise are independent of the owner's preferences, would apply to farmers. The problem arises when farmers are credit constrained, and therefore their preferences play a more important role in where they position themselves on the income-risk tradeoff line. When risk and credit constraints are present, farmers make production choices like planting traditional varieties that result in suboptimal production and consumption levels. This is because farmers cannot or will not buy modern varieties which increases income, and therefore be located in a lower level of the intertemporal budget line and consumption levels would be suboptimal.

2.2.2. Modern bean varieties yield higher than traditional varieties

This section is introduced to support the previous point, regarding differences in income between traditional and modern varieties. First, yields are compared and subsequently, income.

On-farm trials in Honduras indicate that modern bean varieties yield higher than traditional varieties, especially when the optimal amounts of inputs are applied, including fertilizer (Smeltekop, 2005). Analysis of survey data, in contrast to on-farm trials, indicates that the yield differential is mainly due to disease resistance of modern varieties and susceptibility to disease by traditional varieties, especially to the Bean Golden Mosaic Virus (Mather, 2003). Differences in yield due to fertilizer have not been found in survey data. Planting modern varieties do increase expected income in regions where disease pressure is present due to their disease resistance (Mather, 2003) and to drought resistance (Rosas, 2009; personal communication).

Although modern varieties expected yield is higher due to disease resistance, Smeltekop (2005) reported that bean farmers stated that they do not want to risk a low yield in a given year due to terminal drought. Smeltekop defines terminal drought as "when rainfall ends and does not resume over the life of the plant." Smeltekop also reported that drought is the factor farmers expressed to be most constraining to increase yields. The reason farmers pointed out that traditional varieties outperform modern varieties in terminal drought years is that the maturity period for the traditional variety is shorter by 10 days. These results depend upon the region of the country where beans are being produced. Thus, farmers perceive they face an income-risk tradeoff-- they can only obtain a higher expected income by increasing their exposure to risk. As a result, they choose traditional varieties with lower yield variability over modern varieties with higher yield variability. However, Rosas (2009, personal communication) stated that the most recently released modern bean varieties (i.e., from 2007 and later) are more drought tolerant than traditional varieties. Still, many farmers are still with the perception of older improved varieties.

2.2.2.1. Higher income from modern varieties

In Honduras, traders discount the price they pay for modern varieties, due to their darker red color (Martel, 1995; Mather, 2003; Pejuan, 2005). However, due to modern varieties' higher yield, it is thought that they generate a higher net return per hectare—compared to traditional varieties. To assess this hypothesis, a partial budget analysis is presented below, in which one hectare of a modern variety is substituted for a traditional variety (assuming all other costs are the same). The information needed to build the partial budget (Table 3) is the following:

- The price discount for modern varieties is 10-15% in the *Postrera* season (Martel, 1996; Mather, 2003; Pejuan, 2007).
- Cost of modern variety seed and traditional variety grain are L. 33/kg and L. 10/kg, respectively. (Key informant interviews, 2007).

- Modern varieties yield 28% more than traditional varieties (Mather, 2003), assuming that the same quantity of fertilizer (i.e., 2.85 hundred-weight 12-24-12 or 18-46-0 per ha) is applied on both types of varieties.
- Honduran average bean yields of 750 kg/ha (INE, 2007).

Table 3. Partial budget analysis: change in income for substituting one hectare of a modern bean variety for a traditional bean variety.

Increase		
Increased income:	(750 kg/ha * 1.28) * L. 10/kg	L. 9,600
Reduced cost:	0	L. 0
Total increase		L. 9,600
Decrease		
Reduced income:	750 kg/ha * (L. 10/kg * 1.10)	L. 8,250
Increased cost:		
Seed cost	(L. 33/kg – L. 10/kg) * 45.45 kg/ha	L. 1,045
Harvesting and threshing	(750 kg *0.28)* L1.1/kg	L. 231
Total decrease		L. 9,526
Net change		L 74

Since the total change in income is L 74 (L. 9,600 – L. 9,526), it is profitable for a small-scale farmer to switch from growing a traditional to a modern bean varieties, if the farmer buys new certified seed every planting season. However, if farmers amortize the cost of the seed over three planting seasons, then the increased cost item changes to:

((L. 33/kg + L. 10/kg + L. 10/kg) * 45.45 kg/ha)/3 – L. 10/kg * 45.45 = 348

Now, given that the total change is L 771 (L. 9,600 – L. 8,829), it is even more profitable to switch from planting a traditional to a modern variety. Note that the above analysis applies to small-scale farmers. The budget for a large-scale farmer would be different—given that they apply fertilizer at a higher rate per hectare and modern bean yield would be higher.

The change in variety package is also profitable for all villages, since the marginal cost of applying fertilizer (L. 8.94/kg) is less than the marginal income from the additional product (i.e., a minimum of L. 9.22/kg).

2.2.2.2. Perceived higher risk from modern varieties

Previously, it was indicated that risk affects choices. This section denotes farmers' perceptions of modern and traditional varieties and how this affects their choice of which variety to plant.

Smeltekop (2005) pointed out that modern varieties are less drought tolerant than traditional varieties and require more days to mature, which predisposes them to the yield losses due to terminal drought. Thus, it is hypothesized that while modern varieties have a higher yield potential, they also have higher yield variability (i.e., a thicker lower end tails in their yield distribution). This hypothesis assumes that for modern bean varieties, drought is a more important constraint than disease, since modern varieties are more disease tolerant than traditional varieties. If this is correct, the farmer needs to position him/herself on the income-risk tradeoff line according to his/her risk preferences.

Also, as mentioned before, Rosas (2009, personal communication) pointed out that the most recently released modern bean varieties are more drought tolerant than traditional varieties. However, the hypothesis that the probability distribution of the yield of modern bean varieties has a thicker tail than that of a traditional variety is probable in certain villages where some traditional varieties are well established and perform well. This type of relative shapes in the distribution was more an issue of the past (before 2005), when modern varieties had not been bred and released for drought resistance. Nevertheless, it was evidenced in Smeltekop study (2005) that farmers thought, and possibly, currently still think that the relationship persists.

Consequently, concerned about the possibility of drought, some farmers may continue to plant traditional varieties in order to secure at least a minimum amount of production. Furthermore, some farmers plant modern bean varieties that were released more than 15 years ago (1997) when drought resistance had not yet been incorporated into modern varieties, which helps to explain why some farmers still believe that the lower end of the tail of the yield probability distribution is thicker for modern varieties, compared to traditional varieties.

It should be noted that the higher yield from modern varieties (i.e., in partial budget) is an expected higher yield. This means that modern varieties not all years have a higher yield, however, on average modern varieties have a higher yield compared to traditional varieties. The main reason that modern varieties yield higher than traditional varieties in farmers' fields is disease resistance (Mather, 2003) and the main reason modern varieties do not yield higher than traditional varieties in all years is terminal drought (Smeltekop, 2005). The latter depends where in Honduras the beans are being produced. Thus, it makes sense for a risk neutral or low risk averse farmer to choose the modern variety due to its expected higher yield, and it also makes sense for a medium to a high risk averse farmer to choose a traditional variety because of terminal drought years.

2.3. Risk Management

2.3.1. Risk management strategies

According to Ray (1981), farmers can manage agricultural risk by avoidance, prevention, speculation, insurance, and self-insurance (Kurosaki, 1997). Avoidance refers to escaping those risks that are foreseen, which can be largely avoided by moving to production areas where such risky factors are not present (or at least less present) in order to ameliorate the risks. In other literature, researchers refer to avoidance, not by escaping, but by confronting the problem—such as when farmers plant a disease-resistant variety. Prevention refers to the reduction of risk by using improved facilities and techniques and organization. Thirdly, insurance refers to how the farmers mitigate the effect of risk by transferring the risk to someone willing to assume the risk in return of a fee (insurance premium). Self-insurance refers to 1) the accumulation of funds or capital; 2) by operating on a large scale when it reduces correlative risks; 3) pursuing activities that reduce risk by employing risk-reducing inputs; or 4) by farmers diversifying their portfolio of assets.

2.3.2. Risk management strategies used by Honduran farmers

Given the fact that small-scale farmers in Honduras are settled in small villages, with limited access to transportation or capital to buy more land in other regions from farmers in those regions, it is implausible for them to manage agricultural risk by avoidance and prevention, as Ray (1981) defines it. Thus, farmers can only reduce risk through by planting disease- resistant varieties and by purchasing insurance from an insurance company. Even when modern varieties are disease resistant, the perceived income variation due to other factors (e.g., drought, heat sensibility) makes farmers hesitant to switch from planting traditional bean varieties to planting modern bean varieties. To a certain extent, farmers can manage risk themselves by planting several crops, which allows them to diversify their portfolio of assets. The majority of small-scale bean farmers in Honduras plant beans together with corn in relay. Many of these farmers also raise livestock and poultry. These two additional activities diversify farmers' portfolio, which reduces their income risk--possibly to the extent that they perceive the insurance premium to be too high, compared to the risk transferred to the insurance company.

2.3.3. Risk attitudes and portfolio

Individuals' risk attitudes are separated into three categories: (1) risk averse, (2) risk neutral, and (3) risk loving. The income-risk tradeoff that results from the different technologies used by farmers, in combination with their risk attitudes, will determine the portfolio of activities that farmers choose. Generally, farmers are assumed to be risk averse. With evidence of credit constraints, farmers will choose the portfolio that will maximize their expected utility. This portfolio could be improved and yield a higher expected utility by either removing credit constraints or removing risk from a farmer's portfolio.

2.3.4. Diversifiable and covariate risk, and systemic and idiosyncratic risk

Farmers risk can be divided into diversifiable risk and covariate risk. Diversifiable risk refers to the risk of a productive activity that can be mitigated by including more activities. Covariate risk refers to risk that cannot be removed through diversification (e.g., pests, low rainfall). If we assume a farmer faces covariate risk, we could further separate that risk into systemic risk and idiosyncratic risk. The systemic risk refers to the risk that affects all other farmers in the area as well, while idiosyncratic risk refers to the risk associated with the specific farmer. Crop insurance would, in its best scenario, eliminate part of the covariate risk. The part of that risk that it would eliminate would depend on the type of contract. For example, area yield insurance would eliminate more of the systemic risk, while individual yield insurance would eliminate part of both idiosyncratic risk and systemic risk.

2.4. Agricultural Insurance

2.4.1. Types of insurance

In developed countries, there are several types of insurance schemes offered to farmers, including individual yield insurance, area yield insurance, individual revenue insurance (Ray, 1981), and weather index-based insurance (Hess and Syroka, 2005; The World Bank, 2005).

2.4.2. Adverse selection, moral hazard, and basis risk

Asymmetric information problems like moral hazard and adverse selection may cause the insurance market to fail (Rothchild and Stiglitz, 1976; Just, R.; Calvin, L.; and Quiggin, J.; 1999). Adverse selection occurs when the insurance company charges the same premium to farmers with high and low risk (Williams, et.al.1993) due to the information asymmetry of insurance companies not knowing who are the high risk and low risk farmers. Miranda (1991) asserts that farmers will have better information about their outcome distributions and therefore buy insurance, if the benefits outweigh the premiums. It follows that if a concentration of high risk farmers purchases crop insurance but low risk farmers do not due to a relatively high premium, the insurance company will either incur losses, increase their premiums and thereby create a high-risk concentration of farmers, or try to correct the adverse selection through other contract designs. Miranda (1991) and Williams et.al. (1993) also states that moral hazard occurs when a farmer changes production practices that will increase his/her chances of being indemnized. Several approaches in crop insurance contract designs are discussed in the literature that addresses moral hazard and adverse selection problems.

When institutions, that regulate or design contracts, are in place to manage risk aversion and credit, most of these problems are mitigated. Each type of insurance requires different types of data[7], needs different structures in place in the country, and is subject to different problems in varying degrees. For example, to establish an individual yield insurance scheme, the lender needs information about the insured individual's yield history (corroborated with some type of proof). An advantage of this scheme is that farmers are not subject to basis risk (i.e., risk due to the mismatch between when the farmer experience losses and when the farmer gets an indemnity payment). However, individual insurance schemes are vulnerable to problems of moral hazard and adverse selection. On the other hand, area yield insurance schemes do not need information about individual yield history. Instead, they utilize a yield index of an area, which is the trigger for indemnity payments. While area yield insurance has less of a problem with moral hazard and adverse selection, it suffers from basis risk.

2.4.2.1. Group insurance, moral hazard, and adverse selection

Pooling farmers to reduce transaction costs for purchasing insurance could introduce hidden action and hidden information problems (e.g.,high risk farmers might act even more risky when pooled with low risk farmers) (Armendariz and Morduch, 2005).

2.4.3. Weather index-based insurance

Recent research studies that have a promise for increasing insurance participation in developing countries have focused on weather index-based insurance; for example, rain insurance, where farmers receive an indemnity if rainfall falls below a certain level (World Bank, 2011; World Food Program, 2011). Some insurance policies also include excess rainfall triggers since excess rainfall has become a problem in recent years. Weather index-based insurance

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[7] Data for designing insurance contracts are usually not available with the quality required. Rainfall data is available for several rainfall stations. Nevertheless, time series data at the municipality levels are not available and seldom individual farmers have historical yield data.

largely eliminates problems of moral hazard and adverse selection, which reduces the premiums and increase participation--conditional that the index is highly correlated with farmers' yields, so that the basis risk is reduced to the maximum extent possible.

A weather index-based insurance contract should have a well-established system for collecting data on weather-related variables. In addition, weather conditions affecting farmers should not vary greatly from those at the weather station, so that the index and farmers losses are highly correlated. The high correlation will reduce the basis risk.

2.4.4. Insurance and probability distributions

Insurance changes the income probability distributions by changing the possible outcomes. This is because the outcomes, income, and/or expenses change when a farmer purchases insurance and when the farmer is indemnized due to a peril. Due to the change in the probability distribution, a farmer would make an optimal choice of type of variety because the risk is transferred and would reduce the effect of risk on her/his choice.

2.5. Credit

2.5.1. Microcredit history in Honduras

Microcredit in Honduras is offered through small financial institutions called "saving-and-credit rural cashiers". These were established in 1983 by a FAO initiative to help women in rural areas. Eighteen of 24 originally-established rural cashiers still function today (CEPAL, 1999).

These microfinance institutions extend loans to women. These women must be members of the rural cashier, which they join by participating in a training program (CEPAL, 1999).

2.5.1.1. Rural cashiers

In 2002, approximately 2,092 rural cashiers operated in Honduras. Thirty-one percent of these rural cashiers extended loans of less than L. 5,000 and a similar percentage offered loans of between L. 5,000 and L. 20,000. These rural cashiers require mortgage or pledge collateral. Interest rates charges range from 3% to 5% monthly rates[8] (Berdegue, 2000).

2.5.1.2. Grammeen Bank

Fundacion Adelante is the Grameen's Bank microfinance institution partner in Honduras. This microfinance institution mainly serves women in rural areas (http://www.grameenfoundation.org, 2007).

2.5.2. Use of credit and insurance

Implementation of a credit-insurance package for small-scale bean farmers is based on the idea that peril insurance will deal with covariate risk and microcredit will provide access to capital to obtain the modern variety package and also deal with the idiosyncratic risk.

Access to credit allows capital-constrained farmers to acquire cash to purchase modern varieties and complementary inputs (Beke, 2011). Crop insurance reduces risk and may potentially increase the farmers' willingness to purchase modern variety package for risk averse farmers (Gine and Yang, 2008). Thus, a successful credit-insurance package is expected to increase farmers' incomes through the purchase of modern varieties and complementary inputs. With peril insurance, hidden action and hidden information are not much of a problem. As pointed out earlier, when farmers are pooled to reduce transaction costs for purchasing insurance, this could introduce hidden action and hidden information problems.

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[8] Monthly inflation rates in Honduras in 2007 were of 0.6% (Honduran Central Bank, 2007). Thus the real monthly rates range between 2.39% and 4.37%.

2.6. Evaluating Risk

This section presents ways to evaluate farmers' choices (i.e., type of variety package to grow, and use of crop insurance and credit) within a context of risk exposure. One way is an income-consumption model with the use of dynamic programming. Another is a stochastic present value of wealth utility model (SPVWUM) derived from simulated outcomes in multiperiod scenarios with quasi-permanent choices. The use of insurance and credit can be incorporated in both types of models.

To justify the use of crop insurance for bean farmers, there is a need to first assess the level of risk that farmers face with each choice of technology, including the tools that farmers apply to mitigate risk. If farmers choose a traditional variety over a modern variety because of a higher perceived risk, there is a chance that the choice can be reversed if insurance is purchased, assuming that the farmer has access to purchase the modern variety. Both, the income-consumption utility model using dynamic programming and, the SPVWUM can evaluate that kind of farmers' choices. Stochastic events like farmers' yields and prices are incorporated into both kinds of models.

To run a stochastic income-consumption model or a stochastic wealth utility model where farmers perception of yields are evaluated, farmers' yield distributions are required, among other things that are described in this chapter. In addition, even when objective data indicate that farmers would be better off planting modern varieties, sometimes farmers' perceptions of their yield distributions lead them to believe that they are better off planting traditional varieties. Therefore, elicitation of farmers' subjective yield probabilities can help explain to what extent farmers perceive that they face risk and thereby help explain farmers' use of traditional over modern varieties.

The yield distributions would also help explain the participation or lack thereof in insurance schemes. Unfortunately, it is usually not possible to test for differences between objective and subjective probability density functions of small-scale farmers in developing countries like Honduras because objective probabilities are derived from historical data. This would require yield data for at least 15 years, but such data are not available because farmers in Honduras do not usually maintain records of past yields.

Existing insurance policies can be evaluated by comparing farmers' income distributions with and without insurance, and thereby determine the consistency of insurance premiums with farmers' level of risk. This is possible because insurance changes the income probability distributions by changing the possible outcomes. The combination of income probability distribution, outcomes of the distribution, the insured utility function, and the insurance design with its premiums, determine the new risk faced by the insured when they purchase insurance. It is the comparison between these risks (with and without insurance) that determine the extent of risk transfer and the farmers' perceived soundness of the insurance premium, relative to its risk transfer.

2.6.1. Income consumption model

A dynamic model, where households maximize expected utility of consumption, is a starting point for evaluating farmers' decisions on obtaining credit and purchasing crop insurance. Many studies have employed stochastic dynamic programming models, using the Bellman Equation to analyze and optimize choices (Atwood *et. al.*, 1996; Nyambane, 2005).

Studies that use dynamic programming for analysis have the objective of using the Bellman equation to obtain a set of contingency paths that lead the choice maker to maximize utility over time, as she/he responds to possible states of nature in each time period. The different states of nature affect a farmer differently depending on which type of technology and other mechanisms she/he uses to smooth consumption.

2.6.2. Income-consumption model studies

Many household models are framed so that farmers choose among actions to maximize expected utility in their risky decision-making. Deaton (1991), who deviates from the traditional life-cycle models by incorporating a liquidity constraint in the form of a borrowing restriction, shows how consumers use savings to protect their consumption against bad draws. Deaton's main point is to explain household behavior when they are exposed to borrowing constraints. To analyze household behavior, Deaton used programming and simulation based on Bellman's Equation of an infinite horizon expected utility maximizer.

A brief explanation of dynamic programming using the Bellman equation is required at this point. The result of Bellman's equation is a set of decision rules (or policy functions) that indicate the optimal control (or action) to be taken at each time period and possible states of nature. That is, the policy function tells the decision maker a complete set of contingent optimal actions to take according to the unknown states of nature at each period where a decision needs to be made. The state of nature is the realization of an uncertain condition that the decision maker faces. For example, if a farmer wants to decide whether or not to purchase crop insurance over several periods, the previously mentioned state of nature could be the amount of the rainfall in the next growing season which is uncertain, but which is observed for the previous period; then, the optimal choice of insurance could be a function of the amount of rainfall in the previous period according to what the policy function dictates to do for that specific level of rainfall and the possible outcomes related to that state of nature.

Carroll (1997) works with a model that describes saving behavior as a “buffer-stock”, rather than a Life Cycle/Permanent Income Hypothesis model. The main contribution of Carrol is that his model reconciles many behaviors, while other models seem to be able to explain just one type of behavior (i.e., Carroll reconciles the consumption/income parallel and divergence). Carroll uses simulation as a tool and applies it to a finite and infinite horizon expected utility maximizer model. While previous studies assumed that the variance of incomes was constant, Carroll incorporates a variable second-order variance of income. This model is said to be a close substitute of Deaton’s model, since the model is very similar except that Carroll does not directly impose the liquidity constraint and his transitory and permanent shocks are independent. Osborne (2006) recently worked on comparing credit and insurance as substitutes. The main contribution of Osborne’s article is that it contrasts the use of credit and insurance in agriculture in developing areas. To analyze household behavior, Osborne used simulation--based on Bellman’s Equation of an infinite horizon expected utility maximizer.

2.6.3. Utility of wealth models using simulation

Instead of using an income-consumption model where utility is obtained from consumption, we could have a model with income and consumption where individuals obtain utility from wealth. While utility of wealth can be also incorporated in a model using the Bellman equation--like it is done in income-consumption models—using utility of wealth is necessary to do if consumption and choices are held fixed for its scenarios in a multiperiod setting. This way, the different choices yield different ending wealth for each period.

In simulation, choices are represented by the combination of different levels of choice variables and then compared with a certain metric of interest. Sometimes optimization is introduced in studies in a second stage (Berg, 2002).

Crop insurance alternatives and risk management practices have been analyzed using simulations with predefined scenarios and choices (Jansen, 2012; Umarov, 2009). Thus, choices of such as the choice of a technology package (i.e., improved technology package) within certain representative scenarios (i.e., area planted, yields, prices, costs; with its predefined parameters), and the alternatives of use of crop insurance and credit fits well into simulation-scenario-choice analysis[9].

One metric of interest commonly used in insurance studies is expected utility or its counterpart the certainty equivalent. The benefit with these metrics is that it incorporates farmers risk aversion into the analysis.

The certainty equivalent of a risky outcome is the value amount that makes a decision maker indifferent between accepting a sure but lower amount, and the higher expected but risky amount (Usategui, 2009).

In a stochastic multiperiod frame, expected utility can be obtained in many ways (e.g., discounting certainty equivalents from each period, discounting expected utilities at each period, and applying a utility function to net present values). The expected utility is used to obtain the certainty equivalent (CE), since CE is also the inverse of the utility function at the expected utility. A way to obtain the expected utility that appears to be appropriate --compared to several other methods-- is the method where a set of net present values are obtained and later the utility function is applied (Baucells and Sarin, 2007). Thus, to obtain the certainty equivalent, the inverse of the utility function at the expected utility value with the latter method would be appropriate.

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[9] In the business literature, scenarios are the base characteristics. Added to the scenario, stochastic outcomes are added through simulation.

While the objective in dynamic programming is to identify the optimal policy functions that dictate the actions to take depending on the state of nature, in simulation the actions are fixed and the results over several periods of each action are compared to determine which action is preferred. Farmers' most common choice scenarios are compared to observe if farmers' behavior is consistent to that of an expected utility maximizer.

2.6.4. Stochastic dominance (SD)

Another metric for comparing choices is the stochastic dominance criterion. This criterion compares the distributions of the desired variable. For example, if we wanted to compare two variety yields, the yield cumulative distribution functions (cdfs) would be compared using the stochastic dominance criterion. Generally, there are two types of stochastic dominance criterions used, first and second degree stochastic dominance[10]. The three possible results from comparing two distributions using first degree stochastic dominance (FDSD) are: 1) distribution one (choice) dominates the distribution (choice) two in the first degree, 2) distribution two (choice) dominates the distribution (choice) one in the first degree, and 3) neither distribution (choice) dominates in the first degree. The same similar three results are applicable for second degree stochastic dominance (SDSD), except that it is referred to as dominance, or not, in the second degree. When one choice (i.e., a modern variety) dominates a second choice (e.g., a traditional variety) in the first degree with respect to a certain variable (e.g., gross income), all individuals (e.g., farmers) that want more of the variable being analyzed (i.e., want more gross income) will pick the first choice (i.e., modern variety). When one choice

[10] There are other types of stochastic dominance: third degree, fourth, …, nth degree.

stochastically dominates a second choice in the second degree, all risk averse individuals that want more of the variable being analyzed will prefer the first choice.

The criteria for FDSD are the following:

For an increasing utility for x, choice F(x) dominates G(x) in the first degree if and only if $F(\mathrm{x}) \leq G(x)$ for all x with at least one strict inequality, where F(x) and G(x) are the cdfs of choices F( ) and G( ), respectively (Levy, 1973). Thus, FDSD compares the height of the cdfs of both curves at all points, F(x) and G(x).

The criteria for SDSD are the following:

For an increasing and concave utility (i.e., wanting more of something and risk averse) for x, choice F(x) dominates G(x) in the second degree if and only if:

$\int_{-\infty}^{x} F(\mathrm{x}) \leq \int_{-\infty}^{x} G(x)$ for all x with at least one strict inequality, where F(x) and G(x) were previously defined (Levy, 1973). Thus, SDSD compares the area under the cdfs of both curves, F(x) and G(x), at all points.

An advantage of the stochastic dominance criterion is that is free of a utility function. That is, there is no need to assume a particular utility function. The disadvantage of this criterion is that there is no single number to observe when comparing choices, compared to certainty equivalent, and there are many cases where preference of one choice over another cannot be determined for one particular type of farmer.

2.6.4.1. Cumulative Density Functions and intuition to stochastic dominance

A cumulative density function (cdf), F(x), is a function that describes the probability that a random variable "x" is below a specific value (Wilcox, 1996). That is, if "x" is the random variable yield, in kg/ha, from a modern variety and the cdf specifies F(x=1,000)=0.294, it describes that the probability that the modern variety yield will be below 1,000 kg/ha is 0.294, the height of the function at 1,000 kg/ha in Figure 1.

Thus, FDSD is very intuitive-- if a choice, for an individual who always wants more of a good (e.g., yield), always or almost always has a lower probability of being below a specific value but never higher than another choice, the former choice will dominate the latter choice in the first degree.

Figure 2 shows the hypothesized cdfs of yield (kg/ha) of a modern variety and a traditional variety. No variety stochastically dominates the other, neither in the first nor in the second degree. The modern variety does not stochastically dominate in the first degree because the value of the cdf for the modern variety is not always equal or lower than the cdf of the traditional variety. That is, the traditional variety cdf value at the low end of the distribution is higher. Also, the area under the cdf for the modern variety is not always equal or lower than the cdf of the traditional variety. However, the use of insurance with a modern variety might change the revenue distribution and dominate the traditional variety revenue distribution in the second degree (Figure 3).

Figure 1. Cumulative density function of yield (kg/ha) from a modern dry bean variety. For interpretation of the references to color in this and all other figures, the reader is referred to the electronic version of this dissertation.

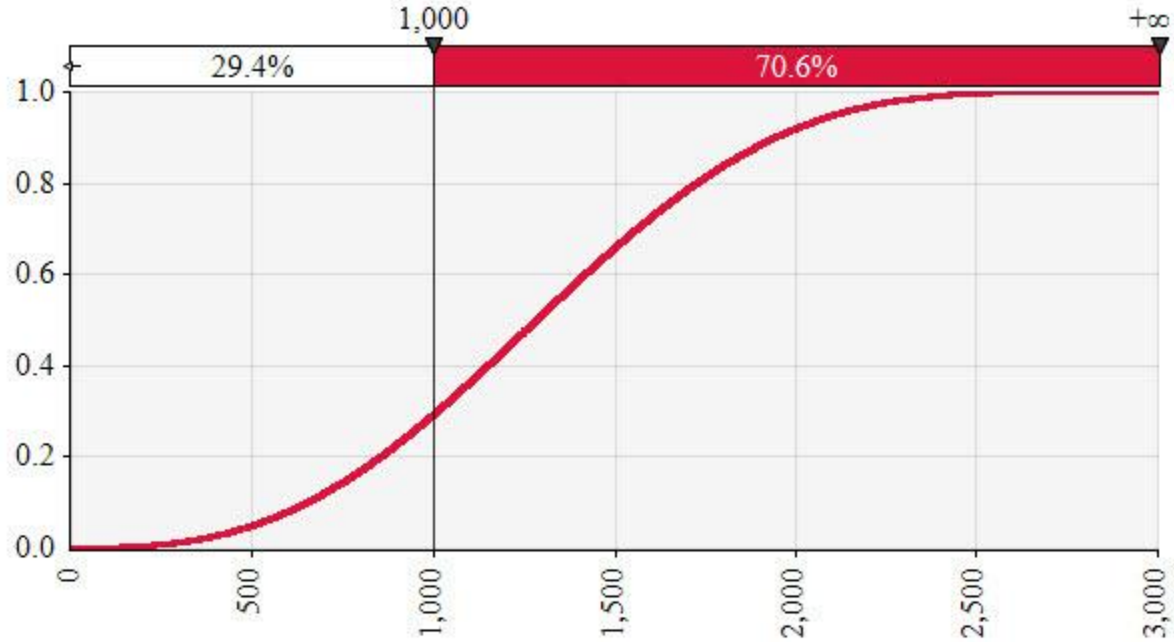
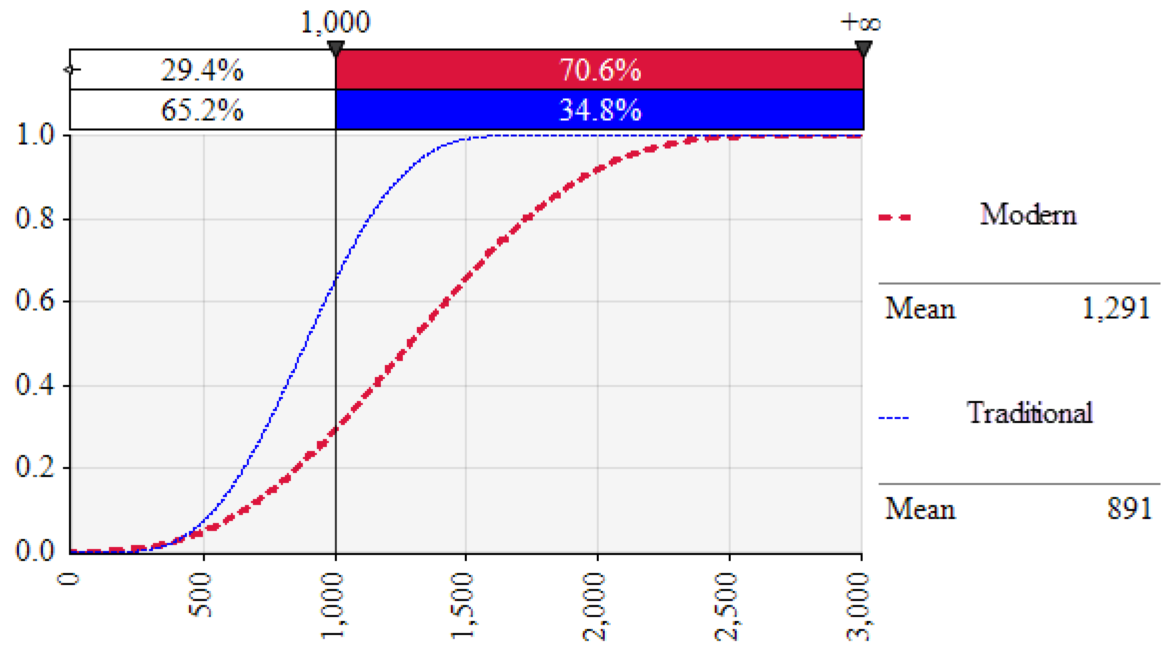
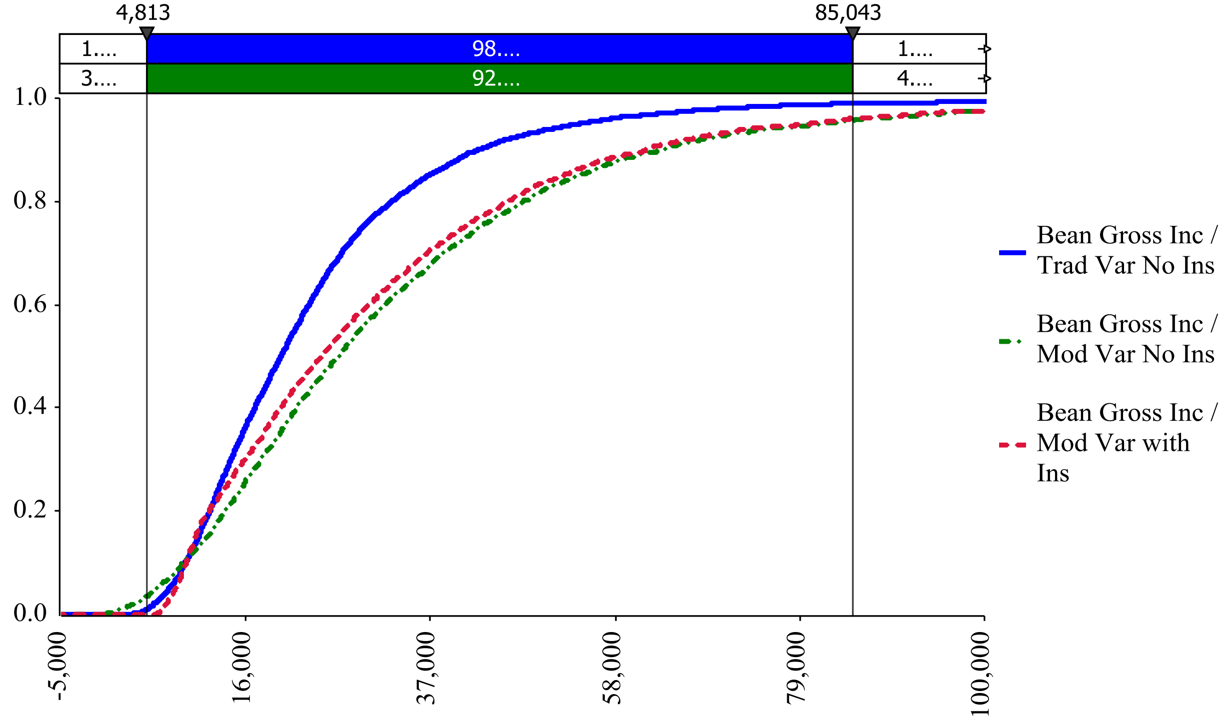


Figure 2. Cumulative density functions of yield (kg/ha) from a modern and a traditional dry bean variety.



The contribution of insurance is shown in Figure 3, where modern and traditional variety gross income distributions without insurance do not dominate each other neither in first degree nor in the second degree of stochastic dominance. However, the modern variety with insurance clearly dominates the traditional variety in the second degree.

Figure 3. Cumulative density functions of gross income (L.) from a modern* and a traditional dry bean variety without insurance and a modern variety with insurance***.**



*The modern variety without insurance is the irregular green dashed curve.
**The traditional variety without insurance is the blue smooth line.
***The modern variety with insurance is the regular red dashed curve.

2.6.5. Improved bean package

Improved variety packages include use of modern variety, fertilizer, and integrated pest management practices. Manuals in Central America for bean farmers recommend use of modern seed, control of pests by using insecticide, and applying fertilizer according to soil analysis. Nevertheless, if a soil analysis is not available, Rosas (2003) recommends fertilizing with 65-130 kg/ha of formula (i.e., 18-46-0 or 12-24-12).

The use of a modern package is said to increase income through increased yields, even though grain prices of modern varieties in Honduras are lower than that of traditional varieties (Smeltekop, 2005). Nevertheless, these modern packages sometimes increase income variability. Thus, research in the use of crop insurance to reduce income variability and increase adoption of modern varieties is needed.

The availability of a credit-insurance package is hypothesized to encourage farmers to adopt the improved bean production package, which includes certified seed, fertilizer (200 lbs of 18-46-0 or 12-24-12 at planting time and 100 lbs of urea before flowering), and timely pesticide application. If credit is available but insurance is not, farmers may not adopt the full modern bean production package, due to their risk aversion. Similarly, if insurance is available, but credit is not, farmers may be unable to adopt the full modern bean production package, due to a lack of capital. Thus, it is hypothesized that a credit-insurance package is a tool that will encourage farmers to adopt the package and increase their income.

2.6.6. Insurance and credit

Honduran farmers are said to be constrained by lack of access to credit (Smeltekop, 2005), which limits their use of a modern variety packages. By helping farmers to mitigate their liquidity constraint, the credit-insurance package will enable them to adopt the whole improved bean production package. By reducing their risk exposure, the credit-insurance package will encourage risk averse farmers to adopt the technology package.

Before establishing the conditions for a credit-insurance package, it is necessary to analyze why farmers do not obtain credit alone or insurance alone when liquidity or risk aversion is and is not a constraint. Reasons why farmers do not purchase insurance when risk aversion is not a constraint include risk exposure, insurance premium, and information asymmetry. On the other hand, small-scale farmers may not utilize credit due to a lack of collateral (liquidity) or because of high transaction costs, both on the farmers' side as well as the lending institutions' side (Armendariz and Morduch, 2005).

The reason insurance markets exist is because of risk aversion (Nicholson, 1998). If farmers were risk neutral or risk loving, which they usually are not, farmers in general would not demand insurance. Thus, we need to know what farmers' risk preferences are. In addition, farmers are able to manage their income risk by creating a portfolio of assets. If the risk associated with the assets in the portfolio is not highly correlated, the portfolio reduces income risk—leaving only some covariate risk. In the farmers' case, the portfolio is composed of income from other crops, off-farm income, and accumulated assets that help reduce their income risk and smooth their consumption. Important questions to answer include: 1) which of these risk management tools (e.g., assets) are the most important?, 2) do farmers use their portfolio to reduce risk, rather than purchase insurance?, 3) do existing insurance schemes transfer significant amount of risk from the insured to the insurance company (i.e., to what extent does insurance reduce the certainty equivalent (C.E.) or income coefficient of variation, compared to when insurance is not present)?, and 4) for the majority of the population that the insurance policy targets, does the insurance premium[11] reflect the risk that is transferred from the insured to the insurer?

Sometimes financial institutions do not offer credit and farmers do not demand it because of the transaction costs involved. Transaction costs incurred by the financial institution include activities associated with handling the loan and reducing risk (e.g., "screening" clients, designing

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[11] If the information asymmetry is high the insurance markets may fail because then the premium becomes too high/unattractive to farmers.

a contract, handling delinquent accounts, and liquidating collateral in case of default). Transaction costs incurred by the farmers include the interest rate, fees, commission, transport and food used to get to the financial institution (Guzman, 2006).

2.6.6.1. Yield and revenue contracts

Insurance companies in Honduras do not offer revenue contracts. Rather, they only offer yield contracts. A comparison between yield and revenue contracts is presented below to show ways that farmers could reduce their risk with each of the insurance products, and how risk would be reduced if revenue insurance was offered. The following section presents a summary of yield and revenue contracts jargon and abbreviations. This will help define and structure the jargon which will be used in the simulation chapter.

Abbreviations:

Y = realized yield

EY = expected yield (in a probabilistic sense)

Cov= Coverage (%)

YG = yield guarantee

Liab= Liability

Loss

IP = indemnity price (price paid in the indemnization of a loss, which is established when the contract is signed)

IND = indemnity

One version of a standard yield contract includes a yield guarantee, loss, indemnity, liability, and premium rate, as defined below:

<u>Yield contract</u> (one version)

YG = (Cov %/100) x EY

Loss = max(YG – Y,0)

IND = Loss x IP

Liab = YG x IP

Rate = average (IND)/Liability

As it is seen in the indemnity function, the yield contract covers any yield shortfall of the actual yield below the covered percentage of the expected yield, priced at the indemnity price.

Parameters of these types of contracts are introduced into simulation-scenario-choice analysis.

For a version of a standard revenue contract, the same contract definitions for a yield contract are defined below:

Revenue contract (one version)

RG = YG x EP

Rev = Y x P

IND = max (RG – Rev, 0)

Liab = RG

Rate = average (IND)/liability

The revenue contract covers any revenue shortfall of the actual revenue below the revenue guarantee, which is priced at a futures price contract.

The difference between yield and revenue insurance is that revenue insurance insures for falling below a certain threshold of income, which is the product of yield and a price, while yield insurance only insures for a shortfall on yield. That means that if price falls sharply and yield remains approximately around its average value, a farmer will not be indemnized, while in the revenue insurance farmers would be indemnized. Thus, the inclusion of the price variable into the revenue insurance contract, which is allowed to vary according to the futures market price, is the source of difference between the two contracts.

2.6.7. Subjective yield distributions

Subjective yield distributions have been used in studies where the distribution of yields of individual farmers is not available. These subjective probabilities then serve to evaluate risky decision making.

Francisco and Anderson (1972) argued that decision makers have a working familiarity with the concept of probability and that subjective probabilities can be readily elicited for important random variables. Another study by Grisley and Kellogg (1983) reports an experiment in Thailand to elicit farmers' subjective probability distributions with respect to price, yield, and net income of selected crops. The elicitation procedure by Grisley and Kellogg (1983) was similar to that of Francisco and Anderson with the important difference that farmers were offered a monetary reward, if their stated expectations turned out to be accurate.

The "visual impact method" or "visual counter" method by Anderson, Dillon and Hardacker was the method used by Grisley and Kellogg as well as Francisco and Anderson. The "visual counter" consists in asking farmers about their minimum yield and maximum yield. After recording both values, the range is divided into five intervals. Next, 25 counters are distributed across the five intervals according to the farmers' belief of the frequency of each yield interval (Grisley and Kellogg, 1983). The result is a frequency distribution (i.e., histogram) from which means, variances, and other statistics can be obtained.

2.7. Factors Affecting Adoption

According to Feder, Just, and Zilberman (1985), factors affecting adoption include risk, credit, input supply, land tenure, social learning, human resource, farm size and information. Feder *et. al.* present information on all those factors previously mentioned, while other studies focus mainly on a few factors (i.e., risk and credit). Feder's *et.al.*broader view of those factors is appropriate to present, however researchers need to prioritize the factors to include in their study due to funding constraints.

2.8. Simulation

With simulation, the stochastic aspect of life is introduced into models and provides a representation of reality in order to comprehend how factors affect the system represented. It provides insight on current and future behavior of agents.

2.8.1. Reasons for using simulation

Crawford (1982) points out to three reasons for using simulation. These are (1) when the objective is to explore the functioning of a whole system, (2) to observe the effects by changing key parameters, and (3) when the system is complex, dynamic, and interactive. The simulation design proposed in this study draws, to a certain extent, from the three reasons stated above. First, there are several constraints that characterize farmers' technology adoption behavior and therefore a comprehensive system should be represented. Second, to answer several of the research questions, key parameters will be changed to observe the effects and predict agents' future behavior and/or justify their current behavior. Third, farmers' decision making, regarding the decision to purchase insurance is dynamic.

2.8.2. Objective

Simulation will provide an opportunity to explore farmers' behavior under different scenarios. This will ultimately translate into a policy suggestions.

2.9. Chapter Summary

Poverty in Honduras is widespread. The introduction of modern bean varieties to farmers is expected to help increase farmers income and reduce poverty. The use of crop insurance and credit encourages farmers to use modern varieties, which on average have higher net returns. Credit access enables farmers that are credit constrained to purchase inputs. Crop insurance potentially reduces the downside yield risk and reduces income variance. The reduction in yield downside risk from the modern variety increases the likelihood that a farmer will choose the modern variety.

In Honduras, most of the country's corn and beans are produced by small-scale farmers, which highlight the importance of focusing on how to improve bean yields. Two of the most important bean-producing departments in Honduras are El Paraiso and Olancho, where farmers on average produce 2.12 and 2.02 hectares during the Postrera, the most important bean production season. The national yield average in the Postrera season is of 702 kg/ha.

Studies have shown that modern varieties recently released in Honduras yield higher than traditional varieties when compared under similar circumstances. Even when this has been documented and advertised, a significant portion of farmers still plant traditional varieties. This leads to ask the following four questions: 1) what are farmers perceptions of the probability distributions of modern and traditional varieties? 2) what are the varieties characteristics that lead to those differences in the distributions? 3) how important is the early-maturing characteristic for bean varieties? 4) under what conditions does crop insurance motivates farmers to change from traditional varieties to improved varieties?

In Honduras, only one crop insurance scheme is available to bean farmers, which is the cost coverage insurance with yield adjustment. This insurance could potentially help smooth farmers' consumption under certain circumstances, but its demand will depend on farmers' risk preferences and income-risk tradeoff.

To farmers, the desirability of crop insurance depends on the farmers' perception of bean yield distributions, insurance premium, income-risk tradeoff, farmers risk preferences and their use of risk management strategies. Depending on the combination of risk-reducing strategies, insurance premiums might be considered too high for farmers' willingness to pay to purchase the insurance policy in return for the risk transfer from the farmer to the insurance company that the policy offers. Nevertheless, insurance companies have to deal with information problems like moral hazard and adverse selection which increases the premiums.

The previously mentioned factors that affect the desirability of crop insurance are used in simulation-scenario-choice models under the form of a stochastic present value wealth utility model (SPVWUM). The use of SPVWUM is to assess if farmers could potentially adopt (i.e., under which conditions) a modern variety package by using crop insurance together with credit.

3. CHAPTER III: Conceptual Model and Methods

This chapter first justifies the use of a stochastic present value of wealth utility model (SPVWUM) to assess if a credit-insurance package will increase adoption of modern varieties. It then presents the simulation model characteristics used in the @Risk general model. The variables and parameters needed to run the model using Excel @Risk 5.7 add-in are specified, as well as the data sources, data collection methods, and the data itself. Finally, it presents the factors (i.e., technology choices and scenarios) to determine and the sequence in which these should be compared to answer if the credit-insurance package will increase adoption of modern varieties.

3.1. Why Simulation?

As noted in Chapter 2, some researchers have used stochastic dynamic programming to evaluate dynamic credit-insurance decisions, including infinite and finite horizon optimization models, and rely on this tool to evaluate farmers' decisions. Some other researchers have used multiperiod stochastic simulation (i.e., simulation of multiperiod sequences) to evaluate the efficacy of insurance decision strategies.

Both simulation and dynamic programming can incorporate stochastic processes and compare choices, but dynamic programming identifies an optimal set of contingency paths, while simulation compares quasi-fixed choices through time to decide among the choices introduced. That is, simulation compares a few selected time paths from the whole set of time paths to then decide which of the paths to take.

However, a drawback of dynamic programming is that as more factors are entered into the model to represent reality, the dimension of the problem increases geometrically (i.e., dimensionality problem) (Bellman and Dreyfus, 1962), which makes programming extremely difficult. Consequently, this study uses simulation.

3.2. Simulation Model

The chosen model for this study is a stochastic present value of wealth utility model (SPVWUM) derived from simulated outcomes in multiperiod scenarios with quasipermanent choices. The stochastic simulation model was applied using Excel add-in @Risk from Palisade.

A utility model captures farmers risk aversion which is the reason for their use of crop insurance and one of the reasons farmers do not adopt technologies like a modern variety package. Wealth instead of consumption is the source of utility in this model because consumption and choices are held fixed or quasi-fixed for the simulation scenarios in a multiperiod setting, and the stochastic outcomes are the driving force along the time path. In addition, its multiperiod setting allows for evaluation of shocks, and decisions with outcomes accrue over time.

Simulation is used, as previously mentioned, for its direct way of comparing among choices; and the stochastic aspect of the model is suitable for representing risky choices. A utility of present value of wealth approach was taken to not violate the principle of time preference of money. Finally, the metric of comparison between choices is the certainty equivalent for being this a currency value and have practical meaning.

3.3. Specifics of the SPVWUM

The SPVWUM is a 20 year simulation model. The model starts in year one with an initial level of wealth. Consumption and stochastic production outcomes change the ending wealth in that year, which then becomes the initial wealth in the following year. The stochastic streams of marginal changes in wealth, which is the difference between terminal wealth of continuous years, are discounted at the appropriate discount rate. The resulting present values of stochastic streams are then introduced into an isoelastic[12] utility function with a constant relative risk aversion coefficient. Finally, the metric of comparison, the certainty equivalent, is estimated. This process is performed for different technology choices and scenarios given the village the farmer is located at. The expected utility model is specified below in equation 1:

$$EU(W) = \sum_{i=1}^{N} U_{icv}\left(W_I + \sum_{t=1}^{T} \frac{MW_{it}^{cv}}{(1+r)^t} \right) \quad \text{Equation 1.}$$

where W_I = initial wealth

U_{icv}= utility for random stream draw i, of choice c, and village v.

MW^{cv}_{it}=Marginal wealth for random stream draw i at time t, of choice c, and village v.

r = is the time preference discount rate

Farmer choices are a combination of types of technology package (e.g.,traditional variety and low inputs, modern variety and high inputs) and options of the credit-insurance package (e.g., insurance only, insurance and credit). Scenarios are a combination of parameters of the credit-insurance package (e.g., insurance coverage level, premium loading factor), and parameters of the farmer (i.e., risk aversion, time preference). Both farmer choices and scenarios are evaluated at different villages, where the village has an effect on production (e.g., yield) and marketing (i.e., price) parameters.

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[12] The isoelastic utility function is used to have a constant elasticity of substitution throughout the range of the function. It also implies that the elasticity of substitution decreases with respect to risk aversion.

The initial wealth, or initial capital, includes the value of farmers' assets: land, infrastructure, machinery, and farm animals. The marginal wealth is the increase or decrease in wealth due to the contribution of gross income from the bean and corn activities. The marginal wealth for random stream draw i, at time t, choice of c, and given village v derive from consumption and production activities from different choices and villages. As mentioned above, the choices farmers have are a combination of technology categories and the use of crop insurance and/or credit for the bean enterprise (i.e., not for corn). The combinations of technology categories and the use of crop insurance and/or credit are presented in Table 4. The metric, certainty equivalent, which will be presented in each of the cells in tables similar to Table 4, will be compared among the choices of interest. Note that not all combinations in Table 4 will be compared because not all combinations are applicable from the standpoint of this research.

Table 5 shows the acronyms for each of the combinations of technology levels, and actions taken by farmers in terms of obtaining credit and crop insurance. This table will be useful when comparing each of the choices within the cases of risk aversion researched in this study. The two cases of interest in this research where the credit-insurance package could be beneficial are: 1) farmers not constrained by capital but who are driven by risk aversion to purchase traditional varieties instead of modern varieties because of the latter failure in drought situations (i.e., risk averse and not capital constrained), and 2) farmers constrained by capital and driven by risk aversion to not access credit to purchase a modern variety and complementary inputs in case of a bad event happening and not being able to repay the loan (i.e., risk averse and capital constrained).

Table 4. Choices (i.e., c=1, …,11) resulting from a combination of technology categories and use of credit and/or insurance that will be compared on the metrics certainty equivalent and insolvency percentage, within each village.

Technology Category/credit and insurance	**Choice number**
Non-mechanized+traditional variety+low input use+no credit+no insurance	1
Non-mechanized+traditional variety+high input use+no credit+no insurance	2
Non-mechanized+modern variety+low input use+no credit+no insurance	3
Non-mechanized+modern variety+high input use+no credit+no insurance	4
Non-mechanized+modern variety+high input use+no credit+with insurance	5
Non-mechanized+modern variety+high input use+with credit+with insurance (switch*)	6
Mechanized+traditional variety+low input use+no credit+no insurance	7
Mechanized+traditional variety+high input use+no credit+no insurance	8
Mechanized+modern variety+high input use+no credit+no insurance	9
Mechanized+modern variety+high input use+no credit+with insurance	10
Mechanized+modern variety+high input use+with credit+with insurance (switch)	11

*Switch refers to the farmer switching back from the actual technology category (e.g., non-mechanized land preparation, modern variety, high input) to the base technology category (i.e., non-mechanized land preparation, traditional variety, low input). The base category for non-mechanized technologies is non-mechanized traditional low input, and for mechanized technologies is mechanized traditional low input. The switch is done when the farmer is no longer eligible for credit by the bank´s standard (i.e., below 1.75 times the farmer´s house value).

Table 5. Acronyms[13] of choices (i.e., c=1, …,11) resulting from a combination of technology categories and use of credit and/or insurance that will be compared on the metrics certainty equivalent and insolvency percentage, within each village.

Technology Category/credit and insurance	**Acronym**
Non-mechanized+traditional variety+low input use+no credit+no insurance	Non-Mech+TV+LoIn+NCr+NIn
Non-mechanized+traditional variety+high input use+no credit+no insurance	Non-Mech+TV+HiIn+NCr+NIn
Non-mechanized+modern variety+low input use+no credit+no insurance	Non-Mech+MV+LoIn+NCr+NIn
Non-mechanized+modern variety+high input use+no credit+no insurance	Non-Mech+MV+HiIn+NCr+NIn
Non-mechanized+modern variety+high input use+no credit+with insurance	Non-Mech+MV+HiIn+NCr+WIn
Non-mechanized+modern variety+high input use+with credit+with insurance (switch*)	Non-Mech+MV+HiIn+WCr+WIn
Mechanized+traditional variety+low input use+no credit+no insurance	Mech+TV+LoIn+NCr+NIn
Mechanized+traditional variety+high input use+no credit+no insurance	Mech+TV+HiIn+NCr+NIn
Mechanized+modern variety+high input use+no credit+no insurance	Mech+MV+HiIn+NCr+NIn
Mechanized+modern variety+high input use+no credit+with insurance	Mech+MV+HiIn+NCr+WIn
Mechanized+modern variety+high input use+with credit+with insurance (switch)	Mech+MV+HiIn+WCr+WIn

*Switch refers to the farmer switching back from the actual technology category (e.g., non-mechanized land preparation, modern variety, high input) to the base technology category (i.e., non-mechanized land preparation, traditional variety, low input). The base category for non-mechanized technologies is non-mechanized traditional low input, and for mechanized technologies is mechanized traditional low input. The switch is done when the farmer is no longer eligible for credit by the bank´s standard (i.e., below 1.75 times the farmer´s house value).

[13] These acronyms are for technology categories and use of credit and insurance. The first section is for type of land preparation, Non-Mechanized or Mechanized. The second section is for the type of variety used: traditional or modern variety. The third section is for the intensity of input use: low input or high input used. The fourth section is for the use of credit: no credit or with credit. The fifth section is for the use of insurance: no insurance or with insurance.

Table 6 shows the relevant comparisons of the certainty equivalents (from Table 4), to assess if the credit-insurance package is beneficial. Other comparisons (i.e., gains from additional inputs) are discussed in the end of this chapter.

Table 6. Proper certainty equivalent comparisons of choices for each of the cases of interest where a credit-insurance package could potentially be beneficial.

Case	Proper Comparison
Risk averse and not capital constrained	Non-Mech+TV+LoIn+NCr+NIn vs. Non-Mech+MV+HiIn+NCr+WIn (i.e., choice 1 vs. choice 5 in Table 4) and Mech+TV+LoIn+NCr+NIn vs. Mech+MV+HiIn+NCr+WIn (i.e., choice 7 vs. choice 10 in Table 4)
Risk averse and capital constrained	Non-Mech+TV+LoIn+NCr+NIn vs. Non-Mech+MV+HiIn+WCr+WIn (i.e., choice 1 vs. choice 6 in Table 4) and Mech+TV+LoIn+NCr+Nin vs. Mech+MV+HiIn+WCr+WIn (i.e., choice 7 vs. choice 11 in Table 4)

The base technology category is the use of a traditional variety with low input (i.e., low fertilizer) for each type of land preparation system. Nevertheless, when comparing each choice, only income and cost change-- the scenario (i.e., village parameters, and technology parameters besides those related to income and cost) remains the same.

The certainty equivalent will provide the lower but guaranteed amount of wealth that will make the farmer indifferent to taking that lower but guaranteed amount compared to taking a higher expected but uncertain wealth.

Another element to note is the switch to the base technology category which is related to what was previously named quasi-fixed choice. In two cases, the choices in the simulation are not completely fixed through time: 1) if the farmer becomes insolvent and therefore stops farming to do off-farm activities and earn the amount equal to the fixed consumption, and 2) when a capital-constrained farmer becomes ineligible for credit, which is needed to buy modern seed and inputs (i.e., modern seed package), is forced to switch from the modern variety package to the base technology category (i.e., traditional low input). That is, the initial choice, for the farmers who with credit are able to buy the modern variety package in a specific year, is the modern variety package, but the choice is changed to the base category because of credit ineligibility.

Marginal wealth from in each period is the difference in ending wealth between periods. It is also each year´s gross income, defined here as revenue minus variable costs. The only source of variation here is in wealth due to chances in production and not consumption. Gross incomes are used instead of ending period wealth to avoid double counting. Marginal wealth can be defined as follows in Equation 2.:

$$MW_{it}^{cv} = I_{it}^{cv} - E_{it}^{cv} \qquad \text{Equation 2.}$$

where I^{cv}_{it}=income from draw i, at time t, for choice c and village v.

E^{cv}_{it}= expenses from draw i, at time t, for choice c and village v.

It is necessary to clarify that the only source of randomness in income is income from crops (i.e., stochastic yields and prices for beans and corn). Consequently, since farmers expenses depend on yield (i.e., harvesting costs), expenses are also stochastic; although it is also the only source of randomness in this variable.

Income from draw i, at time t, for choice c and village v is defined as follows in Equation 3:

$$I_{it}^{cv} = GI_{it}^{mv} + GI_{it}^{cv} + GIOS^{v} \qquad \text{Equation 3.}$$

Where GI^{mv}_{it} =is corn gross income from draw i, time t, and village v.

GI^{cv}_{it} = bean gross income from draw i, time t, and village v, and choice of bean technology c, c=1,…,14.

GIOS= gross income from other sources (i.e., off-farm income, net remittances, and income from other crops, cattle, or business) in village v.

Expenses from draw i, at time t, for choice c and village v is defined as follows in Equation 4.:

$$E_{it}^{cv} = C_{it}^{m} + C_{it}^{c} + HHE \qquad \text{Equation 4.}$$

Where C^{m}_{it}= corn cash costs (i.e., family labor and land is not accounted for) for draw i, at time t.

C^{c}_{it}= bean cash costs (i.e., family labor and land is not accounted for) for draw i, at time t, choice of bean technology c, c=1,…,14.

HHE= household expenses (i.e., food, clothing, education).

Specifics of corn and bean income and costs are specified in the "@Risk general setup" section. However, simulations in this study are modeled as a steady state. That is, prices and yields have the same mean through the 20 year period. It also does not facilitate investment, which means that growth is not incorporated into the model.

3.4. @Risk General Setup

The general @Risk setup is composed of random variables, parameters (constants) and a correlation matrix that correlate each of the random variables with each other. The random variables are a function of the estimated or assumed parameters. The actual values of the parameters, statistics of variables, and correlations are presented in Chapter 4.

The random variables introduced in @Risk are prices and yields for corn and beans, where distributions are conditional on choices and villages. All other elements in equations 1 through 4 are estimated parameters for each of the choices and villages. The correlation matrix contains the pairwise correlations between all random variables (i.e., prices and yields).

Prices and yields for corn and beans in @Risk are defined by probability distribution parameters established for each choice and village. The established yield parameters initially would have come entirely from farmers' elicitation of yield distributions, but as will be explained in Chapter 4, these were rescaled taking into consideration expert opinion. The expert opinion helped shape the scale and variance, of yield distributions for each of the choices and villages. Price distributions come from secondary data (i.e., price coefficient of variation comes from SIMPAH prices) adjusted to primary data characteristics (i.e., mean price of the village from farmer survey).

Equation 1 in @Risk yields the expected utility for a certain choice and scenario within a certain village. The inverse of the utility function is applied at the expected utility value to obtain the certainty equivalent and then compare the choices. Certainty equivalent is used as a metric of comparison instead of expected utility because it is in currency units and not in utils, the unit of measure of utility, and provides a pragmatic version of the outcomes.

Marginal wealth values for choices with crop insurance for the bean enterprise include an indemnity payment and an insurance premium. There is one insurance premium for each technology category or choice with insurance in each village. The indemnity payment depends on the loss function of the crop insurance contract. For this study, a yield contract is used; therefore, the indemnity price multiplies the loss function to estimate the indemnity.

3.4.1. Utility function

The utility function used is an additive utility function with respect to marginal wealth with a constant relative risk aversion coefficient. One of the challenges faced with income-consumption and utility models in general, is that liquidity and other factors are confounded with the risk aversion effect. To mitigate this problem, several coefficients of risk aversion are included in the model.

3.4.2. Quasi-fixed choices

Certain flexibility was given to the model to imitate certain common choices made by farmers when they face certain situations. For example, when farmers reach a certain low threshold of ending period wealth (insolvency), they would stop farming and obtain income from off-farm work. The level of insolvency is established at 1.25 times the value of the house. Similar thresholds were assumed to control when to obtain or stop obtaining credit and insurance. The threshold that would make a farmer not eligible for credit and therefore need to switch back to plan a traditional variety with low inputs is 1.75 times the value of the house. In Chapter 4, the thresholds are described for each choice and village.

Since this study is using simulation instead of dynamic programming the need for credit is assumed from the start of a choice in the simulation (i.e., Non-Mech+MV+HiIn+WCr+WIn) and kept until the farmer is no longer eligible for credit, instead of obtaining credit only when it is needed like it is done in dynamic programming models.

3.4.3. Monte Carlo simulation

To obtain farmers income probability distributions, a Monte Carlo simulation procedure was used. Running the Monte Carlo simulation procedure requires estimates of the probability distribution parameters of corn and bean yields and prices to estimate the probability distribution of revenue. The income probability distributions are then used to obtain the cumulative distribution function of income with and without insurance, and thus, order the uncertain choices. The increasing cdf format is presented because it is easy to observe the probability of observing an outcome below a certain value, which is related to the purpose of this study of reducing downside risk though crop insurance. Also, it is easier to observe if one cdf stochastically dominates another cdf.

3.4.4. Random variables, correlation matrix and parameters

The bean and corn yields were obtained through a mix of elicitation of farmer subjective yield distributions, secondary data, and expert opinion due to problems in the elicitation results. The visual impact method described in Chapter 2 was used to elicit the yield distributions.

Corn and bean price probability distributions are assumed to be lognormal; parameters were estimated from secondary price data and adjusted for each village and technology (i.e., variety type) choices (i.e., due to price differentials in bean variety prices).

A correlation matrix is specified by using secondary time-series data for bean and corn yields and corn and bean prices to obtain the off diagonal terms. This is estimated by obtaining the correlations of the residuals of the regressions of prices and yields on time. The regression on time is required to detrend the regression and obtain the actual correlations.

The parameters used in the models are the following: farmers' discount rate and intertemporal time preference, initial wealth, corn and bean area planted, household expenses, investment according to insurance, insurance premium, bean indemnity price, insurance coverage, premium loading factor, off-farm income, and income of other activities.

Cost has a fixed part and a random part. The fixed component was estimated from the survey data and presented in the parameters section as base fixed cost. The randomness is due to harvesting costs that depends on the stochastic yield.

3.4.4.1. Elicitation of subjective probabilities

The elicitation of subjective probabilities is the source to obtain the yield probability distributions of beans and corn. Other sources of randomness in the simulation model are the bean and corn prices, and bean and corn costs because bean and corn costs (i.e., harvesting costs) are dependent on yields.

The visual impact method was used to estimate the probability distribution, and within itself, the distribution parameters (i.e., the means and variances).

3.4.4.1.1. Visual Impact Method

The visual impact method was implemented by having an enumerator ask the farmers to indicate their maximum and minimum corn and bean yields, independently. Then, the enumerator divided the range into five intervals and asked the farmer to distribute 25 counters among the intervals--according to the farmers' expectation regarding the occurrence of each interval (Table 7 and 8). These counters, along the intervals, are used to estimate the yield distribution parameters (i.e., means and variances).

Tables 7 and 8 show examples of the elicitation of probability yield distributions of bean and corn using the visual impact method. Table 7 shows that the minimum yield stated by the farmer is zero hundred weight (cw) and the maximum yield is 27 cw. The range is divided by five, the number of intervals, and yields 5.4. The decimal part of the ratio (i.e., 0.4*5) was distributed to the lowest and highest intervals, and left the rounded value (i.e., 5 cw) to the middle intervals. Thus, a width of 5 cw was assigned to the middle three intervals and 6 cw to the lowest and highest interval. The same procedure was followed for corn in Table 8 to assign the limits of the intervals.

Table 7. Example of a bean yield distribution, using the visual impact method.

if Min 0 cwt/ha , Max 27 cwt/ha.	(27-0)/5 = 5.4 cwt for each interval; or 5 for each middle and 6 for extremes	
Range in Yield	Counters	Cumulative counters
$0 \leq x < 6$	2	2
$6 \leq x < 11$	4	6
$11 \leq x < 16$	13	19
$16 \leq x < 21$	4	23
$21 \leq x \leq 27$	2	25
Total	**25**	
1 cwt= 100 pounds		

Table 8. Example of a corn yield distribution, using the visual impact method.

if Min 0 cwt/ha , Max 64 cwt/ha.	(64-0)/5 = 12.8 cwt for each interval: or 12 for each middle and 14 for extremes	
Range in Yield	Counters	Cumulative counters
$0 \leq x < 14$	2	2
$14 \leq x < 26$	4	6
$26 \leq x < 38$	13	19
$38 \leq x < 50$	4	23
$50 \leq x < 64$	2	25
Total	25	
1 cwt= 100 pounds		

To obtain expected utility of income, both a particular risk aversion function and a coefficient of risk aversion are assumed[14] to represent a moderate and a high risk averse farmer.

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[14] One of the challenges faced with several income-consumption models is that liquidity and other factors are confounded with the risk aversion effect. To mitigate this problem, several coefficients of risk aversion and liquidity variables are included in the model

3.4.4.2. Insurance and credit

The objective of using a simulation model is to compare bean farmers' expected utility of income with and without insurance and credit. Additionally, different insurance contract parameters are used to evaluate the current insurance contracts and provide insights regarding alternative contracts that could be offered by insurance companies.

3.4.4.3. Insurance contract parameters

To represent the yield insurance contract for the bean enterprise used in the model, several insurance contract parameters need to be established. The insurance contract parameters are the following: bean indemnity price, bean expected yield, coverage, loading factor, and premium. The model does not include any insurance contract for the corn enterprise.

The bean indemnity price established by insurance companies in Honduras was used. The indemnity price is 89% of the expected harvesting period price. Two coverages and two loading factors were used to evaluate premiums paid in Honduras. The first coverage (75%) is from a standard yield insurance contract in the US[15]. The other is based on the coverage offered to bean farmers in Honduras (i.e., 45%).

Premiums used in the model depend on the choices presented previously, as well as on the village. The estimation of premium is shown in the next section.

3.4.4.3.1. Premium evaluation

Honduran contracts will be evaluated according to the premiums and coverages. Additionally, the premiums will be evaluated by estimating the perceived actuarially fair premium and compare it to the actual premium.

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[15] This coverage was selected to have a normative example that could dictate the goal for insurance contracts in Honduras.

To obtain the perceived actuarially fair premium to the farmer, the following loss equation will be used:

$$E[IND] = E[Loss]*IP = E[\max[(YG - Y)(1 - copay), 0]]*IP$$

The actual premium was obtained from key informant interviews with insurance companies' staff.

3.5. Data Collection

The sources of data are from key informant interviews, a farmer survey, and secondary data.

3.5.1. Key informant interviews

Key informant interviews were done with staff of insurance companies, banks and other financial institutions, and scientists. As will be explained in Chapter 4, due to the problems encountered in the data collection from the survey, many parameters were obtained from key informant interviews. The parameters that were obtained from key informant interviews are the following: yield differences between villages for corn and beans, bean yield response to fertilizer, bean minimum yields[16], interests paid on loans (i.e., base for discount rate used in the model), and coverage, premiums, and liability of Honduran bean insurance contracts.

3.5.1.1. Insurance companies

Staff of insurance companies were contacted to obtain information on the contracts offered at the study sites (e.g., the trigger mechanisms, the premiums) to learn about the policies and existing arrangements between the insurance company and farmers. Staff from all six crop insurance companies in Honduras, which are either licensed or on their way to be licensed, were

[16] Bean minimum yields are the bean yields expected in worst case scenario in the village of interest.

contacted and interviewed. These companies are the following: (1) ProAgro, (2) Seguros Interamericana, (3) Seguros HSBC, (4) Seguros Atlantida, (5) Seguros Equidad, and (6) Seguros Continental.

3.5.1.2. Banks and other financial institutions

Key informants from banks and micro-credit agencies that service the region were interviewed to learn about the conditions and services rendered, and to determine their interest in creating a credit-insurance package and what would the conditions be under which they would offer such a product. The staff from the following banks was contacted: Banco Atlantida, Banco de Occidente, BAMER, HSBC, BANADESA, BAC, and Banco Azteca. BAC and Banco Azteca did not provide credit to agriculture, so their staff was not interviewed. Also, a staff member from one of the most influential microcredit organizations in Honduras, ODEF, was interviewed.

3.5.1.3. Scientists

Scientists from Zamorano were interviewed to obtain information on farmers' bean yields, practices, and modern variety adoption. The information collected from the insurance companies, banks, and scientists are reported in the following sections.

3.5.2. Farmer survey

Two hundred forty-five farmers were interviewed for this study. The sampling method and farmer data is presented in the next sections.

3.5.2.1. Farmer sample selection

Eight villages were selected where insurance companies in Honduras were selling bean insurance policies and were perceived by researchers to have the most important types of risks (e.g., drought, excess rain, and high temperatures) for bean farmers. An insurance company provided a list of 34 villages in two of the most productive bean departments in Honduras, Francisco Morazan and El Paraiso. Each of these villages had at least 20 insured farmers. The villages were then categorized by elevation (< 500, 500-1000, and >1,000 m.a.s.l.[17]) and by precipitation (< 300, 300-600, and >600 mm[18]). The villages were randomly selected within each stratum. One village which had very similar characteristics to a village already chosen was dropped and replaced with one with very different characteristics to obtain a wide range in elevation and precipitation. One village was selected randomly within the low and high elevation strata, and six villages were selected from the middle elevation strata[19]. The selected villages are the following: San Pedro Alauca, Chirinos, Arauli, La Cienega, Guaimaca, Talanga, Villa de San Francisco, and Sabaneta de Valle de Angeles.

In these villages, a list of farmers who had most likely not purchased crop insurance was added to the list of farmers who had. Fifteen farmers who had bought crop insurance and 15 who had most likely not were selected for the sample. Later in the field, it was realized that many farmers were afraid to admit they had bought crop insurance because this was a requisite for a loan they had obtained and many of them were delinquent. Thus, the final sample did not balance as previously planned.

3.5.2.2. Farmer data collection

The survey did not collect time series data on farmers' yields and prices for beans nor corn. Rather, it elicited from farmers their subjective probabilities regarding yields; and collected data for the previous year on off-farm income (e.g., paid labor, net remittances),

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[17] m.a.s.l. meters above sea level.

[18] m.m. millimeters of rainfall.

[19] This study is a case study, so the arbitrary selection is not of importance.

household expenditures (i.e., food, clothing, education), use of varieties (bean and corn), use and cost of inputs and labor, use of credit, and general socioeconomic characteristics (household (hh) size, education and age of hh head, assets (land owned, machinery, draft animals, range animals).

The following procedure was performed to obtain an approximate sample size to use. First, a standard deviation of the yield variable, which is of most interest, is needed. Thus, the cross farmer and village coefficient of variation for modern and traditional varieties for the Postrera season (Table 9) was obtained from Mather (2003). The sample size formula derived from the margin of error definition is the following:

$N = (t_{\alpha/2} * \sigma/E)^2$, where *t* is the value from the t-distribution at a significance level α (e.g., 5%), multiplied by the standard deviation, σ, divided by the margin of error.

Table 9. Mean bean yields and coefficient of variation for Postrera season 1999 and 2000, Honduras.

	Postrera 2000		Postrera 1999	
Variety	**Yield (kg/ha)**	**CV (%)**	**Yield (kg/ha)**	**CV (%)**
Modern	537	93	791	53
Traditional	446	80	612	63

CV= coefficient of variation (standard deviation divided by the mean).
Source: Mather (2001) p.33

The margin of error used to calculate the sample size is the amount of kg of beans (134 kg) that is equal in value to the extra cost of fertilizer and extra cost of seed needed to change from a traditional variety technology package to a modern variety technology package. Assuming the cost per hectare of switching from a traditional variety package to a modern variety package is approximately the cost of 90 kg of fertilizer (L. 993), plus the extra cost of seed (i.e., amortized by 3 planting periods) (L. 348). The cost of L. 1,341translated to kilograms of dry beans is 134 kg. The following total sample size is obtained:

$N = (1.96 * 500/134)^2 = 53$

The coefficient of variation in Mather's (2003) is not corrected for village effect so the sample size for each village should be lower. Due to research budget allowing and desire to include a wide range of places, eight villages were surveyed with approximately 30 farmers per village were surveyed.

3.5.2.3. Farmer data

A farmer survey was used to collect data to estimate income and expenses, farmers' capital, and socioeconomic characteristics (i.e., age, education). Selling and consumption prices were valued equally.

3.5.2.3.1. Income

The elicited yield distributions were obtained as well as price data on bean and corn sold. Additionally, other sources of income were collected (i.e., net remittances, off-farm income, and income from other activities).

3.5.2.3.2. Capital

To obtain the farmers level of wealth, data on house value, land value, machinery, and animals owned were collected.

3.5.2.3.3. Costs

The production costs (i.e., input costs, labor costs, mechanization costs, harvesting costs), and marketing costs (i.e., transportation costs) were obtained by directly surveying farmers regarding the amounts and prices of inputs used. Details on how production cost data were obtained are explained below.

Input expenditures were obtained by multiplying quantities used, and prices paid by the farmers. These quantities and prices were collected using the survey instrument.

Labor-days per activity and type of labor were obtained through the survey instrument. Labor days were categorized into family labor and hired labor. Women and men family labor-days were valued equivalently, as opposed to valuing women labor-days less than a man's labor-day as it is done in some studies.

The tractor activities were created in "hours" units instead of "days" units. The total number of hours worked for the tractor activities was calculated by multiplying the number of tractors times the number of hours worked. Similar to the labor-days, two general categories were created for the unlikely event when two or more tractors worked different number of hours; one for hired tractors and another for owned tractors. The total number of hours was recorded in each of these general categories.

Threshing is an activity that had two ways of calculating its cost. One way of calculating the cost was using labor-days and the other was with tractor-hours, depending on which type of threshing activity was done. For the threshing tractor hours, an estimate of the number of hours per unit of harvest weight was estimated; these hours per unit of weight were then multiplied by the total harvest weight to obtain the total number of tractor hours.

Since some farmers prepared land and planted on the same day, these two activities are reported jointly and summarized in one category named "preparation and planting."

Similar to changes made to the inputs' physical quantity outliers, labor-day outliers were also replaced with frontier values. Frontier values were limit values set that a farmer would unlikely surpass, as considered by the author and key informants.

Once the labor-day quantities for each activity were calculated, the labor expense was calculated by multiplying the wage (reported by the farmer) times the labor-days.

The simulation requires households' cash flow per year. Since family labor is, generally, a non-cash expense, its expense was subtracted from the total labor expense. The difference was named "residual labor expense," and was the one used in the simulation.

3.5.3. Secondary data

Secondary data was obtained from the Honduran Market Information System for Agricultural Products (SIMPAH) and the National Statistics Institute (INE). SIMPAH provided price historical data for beans and corn, while INE provided historical data on bean and corn national yields. These data on prices and yields were used to estimate correlation coefficients between them.

3.6. Factors to Compare

Rather than directly testing hypotheses (i.e., value and direction of parameters estimated as it is done with regression), this analysis simulates farmers' actions to see if they are sensible, given their circumstances. In other words, are farmers' actions consistent with the hypotheses that there is no difference in absolute value of simulated outcomes derived from different farmers' actions, compared to the usual positive testing (i.e., there is no statistical difference in observed outcomes derived from different farmers' actions). Farmers' circumstances and environments are simulated and compared in these environments to match the principal factors affecting bean farmers' yields (e.g., rainfall, elevation, disease), perils (e.g., drought, excess rain), technology (e.g., low, high). However, due to a small sample size or because some combinations do not rise naturally (i.e., high elevation, drought and high technology levels), only some of the scenarios were compared. Thus, this study is a case study--it does not provide results that can be inferred/generalized to the population. Rather, the different factors (i.e., elevation, rainfall) that lead to the various farmer environments became subject of target when selecting the villages for the study.

As the literature on technology adoption cites, the lumpiness of a technology packages (i.e., many technology changes in one package instead of one small technology change at a time) is sometimes the reason why farmers do not adopt a technology. For that reason, this study makes comparisons of choices when one item is changed at a time, as well as when the whole technology package is adopted. More specifically, it compares the farmers' certainty equivalent from a base choice to when just the type of variety is changed, or if only a higher amount of inputs is used. Moreover, it also compares that base choice to when all changes simultaneously: type of variety and amount of input use (land preparation was kept constant).

To complement the metric of certainty equivalent, stochastic dominance criterion is applied to order choices. Stochastic dominance is used as a method to order uncertain choices to be able to communicate more efficiently with other disciplines.

3.7. Certainty Equivalents Comparison of Technology Choices

The initial hypothesis stated that small-scale farmers do not plant modern varieties due to the perception of these varieties risk and also because some farmers were unable to buy the seed and other inputs without credit. Thus, there are two types of constraints to test indirectly. One is a hard constraint (i.e., farmer cannot do an action because of the constraint) where we assume farmers need cash to acquire inputs; and the other constraint (i.e., farmer is unwilling to perform an action) is to observe if farmers are driven to use traditional varieties by risk aversion and fear of low yield events. To evaluate these assertions, several comparisons of certainty equivalents are made according to the two cases of interest in this research: risk averse and not capital constrained and risk averse and capital constrained, which are discussed in the following two sections. Additionally, gains from additional inputs are presented in the last section.

3.7.1. Certainty equivalent comparison for risk averse and not capital constrained

To observe if the credit-insurance package is beneficial for a risk averse and not capital constrained farmer, the proper comparisons of certainty equivalents (CE) are the following: 1) compare the CE between the choice Non-Mech+TV+LoIn+NCr+NIn (see Table 10 for acronym codes) and the choice Non-Mech+MV+HiIn+NCr+WIn (i.e., compare CE from choices 1 and 5 from Table 4), given that the farmer prepares land with only labor; 2) compare the CE between the choice Mech+TV+LoIn+NCr+NIn and the choice Mech+MV+HiIn+NCr+WIn (i.e., compare CE from choices 7 and 10 from Table 4), given that the farmer prepares land with mechanization.

Table 10. Acronyms of choices related to technology packages to compare for a risk averse and not capital constrained farmer.

Acronym	Term
Non-Mech+TV+LoIn+NCr+NIn	Non-mechanized+traditional variety+low input use+no credit+no insurance
Non-Mech+MV+HiIn+NCr+WIn	Non-mechanized+modern variety+high input use+no credit+with insurance
Mech+TV+LoIn+NCr+NIn	Mechanized+traditional variety+low input use+no credit+no insurance
Mech+MV+HiIn+NCr+WIn	Mechanized+modern variety+high input use+no credit+with insurance

For a farmer with non-mechanized land preparation and mechanized land preparation, the comparison between choices Non-Mech+TV+LoIn+NCr+NIn vs. Non-Mech+MV+HiIn+NCr+WIn , and Mech+TV+LoIn+NCr+NIn vs. Mech+MV+HiIn+NCr+WIn , respectively, are appropriate. They are appropriate because a risk averse farmer might not want to risk a lower gross income from a modern variety package in case of a bad event, thus the farmer uses the traditional variety package (e.g., traditional variety and low fertilizer). However, by purchasing crop insurance the farmer potentially would be willing to buy the complete modern variety package (e.g., modern seed and high fertilizer). Even with crop insurance it is not certain that the farmer will prefer the modern variety package because it depends on the farmers' level of risk aversion, insurance contract parameters, and gross income parameters from each of the technology packages.

3.7.2. Certainty equivalent comparison for risk averse and capital constrained

The proper comparisons of certainty equivalents (CE) to observe if the credit-insurance package is beneficial for a risk averse and capital constrained farmer are the following: 1) compare the CE between the choice Non-Mech+TV+LoIn+NCr+NIn (see Table 11 for acronym codes) and the choice Non-Mech+MV+HiIn+WCr+WIn (i.e., compare CE from choices 1 and 6 from Table 4), given that the farmer prepares land with only labor (i.e., non-mechanized); 2) compare the CE between the choice Mech+TV+LoIn+NCr+NIn and the choice Mech+MV+HiIn+WCr+WIn (i.e., compare CE from choices 7 and 11 from Table 4), given that the farmer prepares land with mechanization.

Table 11. Acronyms of choices related to technology packages to compare for a risk averse and capital constrained farmer.

Acronym	Term
Non-Mech+TV+LoIn+NCr+NIn	Non-mechanized+traditional variety+low input use+no credit+no insurance
Non-Mech+MV+HiIn+WCr+WIn	Non-mechanized+modern variety+high input use+with credit+with insurance
Mech+TV+LoIn+NCr+NIn	Mechanized+traditional variety+low input use+no credit+no insurance
Mech+MV+HiIn+WCr+WIn	Mechanized+modern variety+high input use+with credit+with insurance

For a farmer with non-mechanized land preparation and mechanized land preparation, the comparison between choices Non-Mech+TV+LoIn+NCr+NIn vs. Non-Mech+MV+HiIn+WCr+WIn , and Mech+TV+LoIn+NCr+NIn vs.

Mech+MV+HiIn+WCr+WIn , respectively, are appropriate. They are appropriate because a capital constrained risk averse farmer is unable to purchase the modern variety package, and if credit would be made available, even then the farmer might not want to use the modern variety package because of the risk a lower gross income and not being able to repay the loan in case of a bad event. Each technology category is assumed to last for the whole 20 years except in the case where ineligibility for credit is reached, in which case the farmer returns to the base category. The ineligibility threshold is valued at 1.75 times the house value. Base category for non-mechanized technologies is non-mechanized traditional low input, and for mechanized technologies is mechanized traditional low input. In addition, if insolvency is reached after having switched to the base category, it is assumed that the farmer keeps working off-farm and stays at the insolvency threshold for the remaining years. The insolvency threshold is valued at 1.25 times the house value.

In summary, without the credit-insurance package some farmers would probably select the traditional variety package and with the credit-insurance package, the farmer might use the modern variety package. Again, it is not certain that the farmer will prefer the modern variety package even with the credit-insurance package because it depends on the farmers' level of risk aversion, credit and insurance contract parameters, and gross income parameters from each of the technology packages. Thus, both credit and crop insurance need to be available to risk averse and capital constrained farmers. Credit is needed for purchasing the modern seed and inputs, and the crop insurance is needed to be able to repay the loan in case of a bad event.

3.7.3. Gains from additional inputs

Traditional and modern varieties respond to fertilizer. Similar to the comparison of a modern variety to a traditional variety, using a high level of fertilizer produces a lower minimum yield and lower gross income than a low fertilizer level when a bad event (i.e., drought) occurs. Nevertheless, for both types of bean varieties a high level of fertilizer is expected to have a higher gross benefit than a low level of fertilizer in. This tradeoff of having a higher net benefit at the cost of a lower minimum net benefit (i.e., the expected minimum net benefit when a bad event occurs) when applying high level of fertilizer, creates a similar response in risk averse farmers like when comparing modern and traditional varieties. However, the effect of the levels of fertilizer on risk averse farmers might not be of the same magnitude because the difference in yield between minimum yields (i.e., the lowest expected yield when bad events occur) for the low and high fertilizer level is lower than the difference between the minimum yields of the modern and traditional varieties.

To observe the gains from additional inputs for a risk averse and not capital constrained farmer, the proper comparisons of certainty equivalents (CE) are the following: 1) compare the CE between the choice Non-Mech+TV+LoIn+NCr+NIn (see Table 12 for acronym codes) and the choice Non-Mech+TV+HiIn+NCr+NIn (i.e., compare CE from choices 1 and 2 from Table 4), given that the farmer prepares land with only labor (i.e., non-mechanized); 2) compare the CE between the choice Non-Mech+MV+LoIn+NCr+NIn and the choice Non-Mech+MV+HiIn+NCr+NIn (i.e., compare CE from choices 3 and 4 from Table 4), given that the farmer prepares land with only labor; and 3) compare the CE between the choice Mech+MV+LoIn+NCr+NIn and the choice Mech+MV+HiIn+NCr+NIn (i.e., compare CE from choices 7 and 8 from Table 4), given that the farmer prepares land with mechanization.

Table 12. Acronyms of choices related to level of fertilizer to compare for a risk averse and not capital constrained farmer.

Acronym	Term
Non-Mech+TV+LoIn+NCr+NIn	Non-mechanized+traditional variety+low input use+no credit+no insurance
Non-Mech+TV+HiIn+NCr+NIn	Non-mechanized+traditional variety+high input use+no credit+no insurance
Non-Mech+MV+LoIn+NCr+NIn	Non-mechanized+modern variety+low input use+no credit+no insurance
Non-Mech+MV+HiIn+NCr+NIn	Non-mechanized+modern variety+high input use+no credit+no insurance
Mech+TV+LoIn+NCr+NIn	Mechanized+traditional variety+low input use+no credit+no insurance
Mech+TV+HiIn+NCr+NIn	Mechanized+traditional variety+high input use+no credit+no insurance

The comparisons for fertilizer levels above are appropriate for farmers in the same region because each of the three comparisons is a movement from a low fertilizer level to a high fertilizer level, given a type of variety and land preparation system. However, this assumes that the native fertility of the soil for farmers in the same region is similar.

3.8. Chapter Summary

The study uses a simulation model instead of dynamic programming because simulation modeling allows a straight forward comparison of choices and villages. The Excel add-in @Risk was used to estimate stochastic present value of wealth utility model (SPVWUM) to generate a Montecarlo simulation process. SPVWUM integrates income and expenses to generate the marginal wealth along the multiperiod model.

Yield and price variables, along with parameters of wealth and time preferences, insurance contract characteristics, other sources of income, and household expenses were used in the SPVWUM. The yield distributions used in the study were obtained through a mix of elicitation of farmer subjective yield distributions, secondary data, and expert opinion due to problems in the elicitation results, as will be explained in the next chapter. Yield and prices were modeled as a steady state having the same means throughout the 20 year period of the simulation. Growth was not incorporated into the model.

Certainty equivalent was the metric used for comparison between farmers choices.

Data were collected through key informant interviews with staff of insurance companies, banks, and scientists and a farmer survey. Additionally, secondary data from INE and SIMPAH was collected to obtain several simulation parameters.

Finally, cases of interest to determine if the credit-insurance package is beneficial were presented along with the proper comparisons of the certainty equivalents. The cases of interest are: 1) risk averse and not capital constrained farmers and 2) risk averse and capital constrained farmers. Additionally to the cases of interest, several comparisons for gains from additional inputs are presented.

4. CHAPTER IV: Data Analysis and Information Collection

The following chapter summarizes the information collected from key informant interviews, survey data and secondary data collected mostly in 2007. The key informants included personnel from insurance companies, banks, microcredit institutions and scientists. The farmer survey was used to collect information to estimate key parameters used in the stochastic present value of wealth utility model (SPVWUM). Finally, the chapter summarizes the parameters used for the different runs of the model for final comparisons between choices.

4.1. Key Informant Interviews

4.1.1. Crop insurance history in Honduras

After hurricane Mitch in 1998, industrial firms like Demasah and Alianza, who usually has financed farmers, saw the necessity to insure crops (Erazo, 2007; personal communication). These firms had built relationships with firms in Mexico and asked ProAgro, the largest insurance company in Mexico, to help design, establish, and develop insurance programs to protect against extreme weather events (ProAgro website, 2007). ProAgro started insuring farmers first in Guatemala and Honduras, and later included El Salvador and Nicaragua (ProAgro website=http://www.proagroseguros.com.mx/historia.html).

The first insurance company to offer crop insurance in Honduras was Seguros El Ahorro Hondureño along with ProAgro Honduras as a reinsurer. El Ahorro Hondureño is currently part of HSBC[20].

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[20] El Ahorro Hondureño merged with Bancahsa (Bancahsa bought El Ahorro Hondureño) in July 2000 (http://reseau.crdi.ca) to form a new bank called BGA (Banco Grupo El Ahorro Hondureño). BGA was later bought by HSBC in July 2006 (http://www.hsbc.com).

4.1.2. Crop insurance rules and regulations

Crop insurance in Honduras is regulated by the Insurance Superintendence (IS), which is a subdivision of the Superintendence of Banks and Insurance (SBI).

The IS works with funds provided by the Central Bank of Honduras as well as fees charged to insurance companies, which come from a percentage of the premiums paid to the insurance companies. Insurance companies obtain their insurance policy approved by presenting to the IS a proposal of an insurance policy. The IS personnel revise the policies and suggest and/or require changes in the policy. Finally, a resolution is made. The required time from a submitted policy to when the submitter receives an answer is 30 days. Nevertheless, when new products with its own complexities are submitted to the IS, the time required for actual resolution is much greater than 30 days. An insurance company that does not abide by these rules and regulations is sanctioned pecuniarily and/or legally.

Crop insurance in Honduras has been compulsory from 2002 to the present (except for one year) at the Honduran development bank, BANADESA. It has remained at private banks' discretion to make it compulsory or not for their clients.

All crop insurance contracts offered in Honduras do not take quality of produce into account. Quantity is the only factor included for indemnization.

A crucial part of the indemnization is the yield adjustment. Yield adjustment is done by a contractor of the crop insurance company, which might lead to a conflict of interests. In any event, a farmer can formally complain about a yield adjustment done by an insurance company contractor by filing a complaint to the Chamber of Commerce and either conciliate or go to arbitration. In the conciliation, the insured and insurer would try to come to an agreement but it has no legal standing. The unsettled differences would be determined by the arbitration. If the parties go to arbitration, disagreements will be settled by a committee of arbitrors, which are uneven in number. The decision taken by the arbitration committee is usually final. In rare circumstances, there is nullity recourse or reposition recourse.

4.1.3. Insurance companies

The Insurance Superintendence has extended crop insurance permits to the following crop insurance companies: (1) Seguros Atlantida, (2) Seguros HSBC and (3) Interamericana de Seguros (currently, Seguros Ficohsa). Nevertheless, Seguros HSBC and Interamericana de Seguros did not insure directly but operated as a fronting company for ProAgro, a Mexican insurance company. Seguros Equidad was about to get licensed and Seguros Continental was about to start the process to obtain a license in October 2006.

4.1.3.1. ProAgro

ProAgro is a firm operating in Honduras, which does not operate in Honduras as an insurance company per se, but it acts as an insurance agent, while HSBC does the fronting for them. Fronting is the process by which these insurance companies do all the legal insurance paperwork for a fee, but transfer all the risk to the reinsurer ProAgro. Nevertheless, ProAgro is in charge of advertising, setting insurance premiums, assessing risk, and explaining the contracts to clients. Interamericana de Seguros has an arrangement with ProAgro similar to HSBC, except that risk is shared.

ProAgro in Honduras started insuring corn and sorghum farmers in 2001. In 2002, crop insurance was promoted together with the “Monedero Agricola.” The Monedero Agricola was a program that used to extend credit to farmers that was implemented from 2002-2006. Credit was extended by BANADESA by issuing credit cards, where the products that the farmer could buy were limited to agricultural inputs.

ProAgro offers five types of contracts: (1) Investment Cost Coverage with Yield Adjustment (ICCYA) (2) Yield Insurance with Production Cost Adjustment (YIPCA), (3) Tree Crop Insurance (4) Direct Damage Scheme, and (5) Compensatory Insurance Scheme. The insurance contract offered to bean growers is the ICCYA . The trigger in this type of contract is given by three distinct and separate steps: (1) the peril insured for needs to occur, (2) notification from the insured to the insurer about a loss, and (3) damages to the crop need to be related to the peril.

The indemnity formula for the contract of ICCYA is the following:

$$E[IND] = E[Loss] * IP = E[\max[(YG - Y)(1 - copay), 0]] * IP$$

The indemnity formula is applied once the steps for the trigger are fulfilled.

ProAgro, working through its fronting collaborators, charge bean insurance premiums from 8% to 10% of the insured amount depending on the amount of land insured and region of the country. Insurance price[21] for a kg of bean have ranged from L. 8.8/kg to L. 9.9/kg. The copay schedule for different perils or mix of perils insured by ProAgro is shown in Table 13.

Table 13. Copay (% of loss) schedule for type of peril insured.

Type or mix of perils insured	**Percentage**
Wind	10
Excess rain	10
Flood	15
Low temperature	15
Wind and excess rain	10-15
Hail	20
Drought	30
Drought, excess rain and wind	30
Source: Pejuan Bean Key Informant Interview, 2007.	

[21] Insurance price is the price at which production is value for indemnity purposes; also called indemnity price.

Yield adjustors are employees of ProAgro, but since ProAgro is not the company extending the contract, it acts as an independent company exercising the yield adjustment.

ProAgro insures individual bean farmers in a region that farm less than 100 km away from the insurer headquarter, if there are at least 7 ha to be insured. If the place is farther than 100 km and less than 200 km away, ProAgro would insure individual farmers, if the farmer insures at least 14 ha. For a collective policy (i.e., a policy with more than one beneficiary), ProAgro insures farmers with at least 0.35 ha, but where the sum of the hectares is greater than 21 ha, as long as they are located less than 200 km away. Nevertheless, if a farmer wanting to insure a crop with a land area no less than 0.7 ha and it is near a place where there are already other insured farmers, ProAgro would sell the contract to the farmer.

ProAgro's crop insurance contractual procedure, done through its fronting agents, is the following: (1) filling of application form, (2) risk assessment, (3) risk acceptance, (4) quote, (5) subscription visit, (6) policy emission, (7) payment of premium, (8) follow-up visit, (9) alert of peril, (10) yield adjustment, and (11) indemnization.

ProAgro also extends contracts to groups of farmers, which works the same way as the individual contract where the insurer only deals with one person for payment purposes, except that claims and indemnizations are done individually by each member in of the group.

4.1.3.2. HSBC

Seguros HSBC does fronting for ProAgro. The only function of Seguros HSBC is to do the paperwork for ProAgro. This means that even though farmers sign the contract emitted by Seguros HSBC, it is ProAgro who assesses the risk and establishes the contract parameters. Farmers need to notify ProAgro for any loss due to a peril instead of Seguros HSBC.

4.1.3.3. Seguros Interamericana

Seguros Interamericana[22] is the other company doing fronting for ProAgro. This company made available crop insurance policies in 2005. Nevertheless, it had not sold any bean insurance policy up until October 2007, at the time of the interview. Seguros Interamericana offers two types of contracts: (1) ICCYA, and (2) YIPCA. The difference between the relation of HSBC and ProAgro, and Seguros Interamericana and ProAgro, is that Seguros Interamericana does share some risk with ProAgro, while HSBC does not bear any risk; and farmers can notify either Seguros Interamericana or ProAgro about a loss due to a peril. By October 2007, Seguros Interamericana had not sold any group policies, but were considering it.

4.1.3.4. Seguros Equidad

In October of 2006, Seguros Equidad was on the approval process to become a certified crop insurance company. It had not offered any crop insurance policy, but instead had trials in farmers' fields. Seguros Equidad offered weather-based index crop insurance policies for one time only in 2008. The company had the support of the World Bank, which had the objective to include small-scale and medium-scale farmers. Seguros Equidad has been the only insurance company who has offered weather-based index crop insurance. Seguros Equidad made alliances in 2008 with meteorological stations to obtain and publicize, in the period of the contract, the index to farmers, which would include the trigger of the contract. The first crop covered as a tryout by Seguros Equidad was corn, but they are planning to expand to other crops. The insurance contract to be offered by Seguros Equidad is that of production cost coverage. Premiums and insurance price were not established at the time of the interview. The insurance

[22] Seguros Interamericana is now Seguros Ficohsa.

contract was planned to be for individual or groups of farmers. The purpose of offering crop insurance is to insure those farmers who request credit, and the indemnization would be paid directly to the financial institution instead of to the farmer.

4.1.3.5. Seguros Atlantida

Seguros Atlantida started designing crop insurance contracts in 2002 and started operations in 2003. Seguros Atlantida offers three types of contracts: (1) ICCYA, (2) YIPCA, and (3) Tree Crop Insurance. The insurance contract offered to bean growers is the ICCYA. The trigger in this type of contract is given by the same three distinct and separate steps as it is for PROAGRO: (1) the peril insured for needs to occur, (2) notification from the insured to the insurer about a loss, and (3) damages to the crop needs to be related to the peril.

The indemnity formula for ICCYA is the same as for PROAGRO.

Crop insurance is compulsory for some crops for credit seekers from Banco Atlantida. Seguros Atlantida charges a premium between 6 and 12 % depending on the perils covered and the estimated risk of the farmer. For instance, farmers with irrigation systems have been charged a premium of 6% and those without irrigation 8%. The copay for perils that do not include drought is 15% of the loss. If drought is included in the perils covered, even if it is the only peril insured, the copay is that of 20% of the loss.

Seguros Atlantida started operating with premiums and insurance prices set by the reinsurer, based on the experience of those companies in other countries. With the passage of time and experience, Seguros Atlantida has been readjusting their premiums.

Seguros Atlantida extended bean insurance for the first time in 2004. For an ICCYA type of contract, three terms need to be specified: (1) the insured amount (2) the bean insurance price per weight measure at time of buying the policy (indemnity price), and (3) the copay according to the peril(s) insured.

Seguros Atlantida does extend contracts to groups of farmers, which works the same way as the individual contract, except that the insurer only deals with one person for payment purposes, but claims and indemnizations are done individually by each member in the group.

Seguros Atlantida insures bean farmers in a region that are less than 100 km away from the insurer headquarter, if there are at least 18 ha insured. If the place is farther away than 100 km, there must be at least 35 ha. Nevertheless, if a farmer wanting to insure a crop with a land area no less than 0.7 ha and farms near a place where there are already other farmers insured, Seguros Atlantida would sell the contract to the farmer.

Seguros Atlantida has two reinsurers, Swiss RE and MAPFRE RE. Among other things, the reinsurer trains the yield adjustment personnel. Yield adjustors are not Seguros Atlantida's employees, but are contracted by Seguros Atlantida. There have been a few complaints due to the yield adjustments, but none have transcended to arbitration.

The crop insurance contractual procedure is the following: (1) filling of application form, (2) payment of premium, (3) hand out of contract copy, (4) alert of peril, (5) yield adjustment, and (6) indemnization.

4.1.4. Credit and microcredit

4.1.4.1. Credit

Several banks offer credit to farmers in Honduras. Some of the most important banks involved in lending to the agricultural sector are listed in the following section.

4.1.4.1.1. BANADESA

BANADESA, the agricultural development bank of Honduras, extends loans to small-scale farmers. The types of loans extended are fiduciary, with a pledge, or with mortgage collateral. The fiduciary loan requires two guarantors; the pledge guarantees a loan in the amount of 40-50% of its appraised value; and the mortgage guarantees a loan in the amount of 60% of its appraised value. Loans are at the minimum amount in the order of L. 15,000 and at maximum at L. 300,000. Loans are conditional on crop insurance and the farmer can buy crop insurance from any of the crop insurance companies.

Annual interest rates are of 10%. The payback of the loan is after six months in one lump sum. BANADESA has arrangements with insurance companies that if the farmer purchases crop insurance the premium would be deducted from the loan and paid to the insurance company, and in case of forfeit due to a peril, the insurance company would pay the bank and the farmer is exonerated from the debt.

BANADESA does not have any arrangements with rural cashiers[23] for providing microcredit to farmers. Rural cashiers need to handle their loans efficiently, which could be from funds of BANADESA, since the risk falls on them and not on the borrowers. BANADESA extends loans to rural cashiers in the range of L. 15,000 to L. 150,000 for the first two loans and up to L. 300,000 from the third loan and onward. Life insurance is a requisite for all borrowers.

[23] Rural cashiers are organized legal entities with the purpose of providing credit to small-scale farmers.

4.1.4.1.2. BAMER

BAMER[24] generally requires loans with one type of collateral, a mortgage. Guarantors, usually a requisite in the fiduciary type of loan, are a complement of mortgage. Pledges are restricted to a few set of assets and are also a complement to the mortgage. Mortgage collateral needs to be an urban property and serves as a guarantee for 70% of its appraised value. Pledges are also guarantee for 70% of their appraised value.

The minimum amount of a loan is L. 944,500[25]. The maximum loan covered by the Small and Medium Firm division of BAMER is of L. 18,890,000. Prior to 2006, loans were given for a minimum of L. 10,000. This big difference has been due in part because BAMER is not financing the agricultural sector unless it's a known client with guarantees. Interest rates charged are from 12-15% with mortgage collateral, 15-17% with a pledge, and 19% if a fiduciary guarantee is provided. BAMER does require crop insurance to extend a loan. The crop insurance must cover drought, wind, and excess rain. Insurance can be bought from any insurance company in Honduras. The payback of the loan is after nine months in one lump sum. If a borrower is late with his/her payments, the following steps are taken: (1) call or notify the client, (2) accept or reject justification, (3) readjust loan terms or sent to judicial department. If farmers are late due to catastrophic events, the loan terms are adjusted as follows: (1) extend the time period to pay, and (2) lower interest rates. BAMER does not have any arrangements with rural cashiers nor do they provide microcredit.

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[24] Currently, BAMER is the Central American Bank (BAC).
[25] Exchange rate is L. 19.03/US$.

4.1.4.1.3. Banco Ficohsa

Banco Ficohsa generally requires a mortgage as collateral for its loans. The fiduciary type of loan needs a reputable guarantor. Pledges need to be easily liquidable. Mortgage collateral needs to be an urban property and serves as a guarantee for 70% of the appraised value. Pledges are a guarantee for 50% of its appraised value.

The minimum amount of a loan is L. 25,000. The maximum loan handled by the credit committee is of L. 5,000,000.

Interest rates charged are from 10-14%. Interest rates are greater as the time to repay increases and if repayment is in a lump sum instead of several installments.

Banco Ficohsa does require crop insurance to extend a loan. The crop insurance must cover drought and excess rain. Insurance can be bought from any insurance company in Honduras. If a borrower is late with his/her payments, the following steps are taken: (1) call or notify the client, (2) accept or reject justification, (3) readjust loan terms or sent to bank's judicial department. If farmers are late due to catastrophic events, the loan terms adjusted are the following: (1) extend the time period to pay, and (2) lower interest rates.

Loans are usually not extended for a bean investment only, but it needs to be accompanied with another investment due to the high risk Banco Ficohsa perceives as being associated with the grain sector. Banco Ficohsa does not have any arrangements with rural cashiers nor do they provide microcredit.

4.1.4.1.4. Banco HSBC

HSBC generally does not extend loans for growing grains, including beans. It only extends these loans to clients who have a long credit history with them. HBSC's policy is a result of high risk and governmental decrees that have led to a behavior by borrowers of not repaying loans. For those clients to whom HSBC extends loans for beans, HSBC requires mortgage and pledges as collateral. Fiduciary collateral are rarely approved. The mortgage collateral needs to be an urban asset and serves as guarantee for 70% of the appraised value. The pledge serves as guarantee for 30% of its appraised value.

The minimum loan amount for small-scale farmers is L. 100,000. The maximum, within the small-scale qualification, is of L. 1,130,000.

Interest rates charged range from 14-18%, with no reduction in the interest rate due to crop insurance.

HSBC may or may not require the farmer to obtain crop insurance. The farmer may choose his own insurance company.

When farmers are late with their payments and no arrangements have been made between the bank and the borrower after 60 days, the account falls under administrative delinquency and several notices are sent to the farmer. After 90 days, delinquency accounts go to judicial department and collaterals are liquidated.

HSBC does not have any arrangements with rural cashiers or groups of farmers for extending loans, nor do they provide microcredit.

4.1.4.1.5. Banco de Occidente

Banco de Occidente (BO) provides conventional credit to farmers, to microcredit institutions, and to farmers' groups.

BO requires mortgage or fiduciary collateral for a loan. Pledges are accepted as complement of mortgage collateral. Mortgage collateral can be an urban or rural property and serves as guarantee for 70% of the appraised value.   Fiduciary collaterals need to present proof of monthly income three times higher than the monthly financial installments to repay the loan.

The minimum amount of a loan is L. 100,000. The maximum loan is of L. 1,200,000 to a fairly new client and up to L. 3,000,000 to a client with credit history.

Interest rates charged range from 12-16%, with no reduction in the interest rate due to crop insurance. Borrowers with credit history are charged 12% and those without or with very little credit history are charged interest rates from14-16%.

Crop insurance is not a requisite for obtaining a loan. When farmers are late with their payments and no arrangements have been made between the bank and the borrower, the account goes to the recuperations department. Nevertheless, flexibility is usually given in the form of longer time period to repay the loan.

BO extends loans to farmer groups and microcredit institutions through conventional credit and no arrangements or special considerations are given to these borrowers. The farmer group and microcredit institution bears the risk when these extend loans to individual farmers. BO does not provide microcredit.

4.1.4.1.6. Banco Atlantida

Banco Atlantida (BA) generally does not extend loans for growing grains, including beans. It only extends these loans to clients who have a long history with them. For those bean farmers that BA does extend loans to, BA requires mortgage or fiduciary collateral. The mortgage collateral could be an urban or rural asset and serves as guarantee for 50% of the appraised value.

The minimum amount of a loan for a small-scale farmer is L. 10,000. The maximum, within the small-scale qualification, is L. 3,000,000.

Interest rates charged vary according to the borrower’s credit history and if they have insurance or not. A new client with insurance is charged 16%, while those without insurance are charged 18%. A client with credit history and crop insurance would be charged 13%, while those without insurance could be charged 16%. For bean farmers who have a long credit history with the bank, crop insurance is required and it needs to be from Seguros Atlantida. Other bean farmers would not get credit.

When farmers are late with their payments and no arrangements have been made between the bank and the borrower, after 90 days the account falls under administrative delinquency and several notices are sent to the farmer. After 180 days, delinquency accounts go to the judicial department and collaterals are liquidated. BA does not have any arrangements with rural cashiers or groups of farmers for extending loans, nor do they provide microcredit.

4.1.4.2. Microcredit

There are around 21 microcredit institutions in Honduras that are associated with the REDMICROH (Honduran Net of Microfinance Institutions). REDMICROH is a non-profit civil association that coordinates activities among its members to promote microfinance projects. Key informants identified ODEF (Feminine[26] Entrepreneurial Development Organization) as one of the most successful and largest microfinance institution in Honduras.

4.1.4.2.1. ODEF

Staff from ODEF indicated that microcredit was not extended to bean related activities when this was the only activity of the farmer. ODEF would only extend credit to the farmer if activities besides agriculture, with less risk, are involved. ODEF staff also noted that microcredit institutions in Honduras, in general, followed the same policies of not lending for agricultural activities only. ODEF extends microcredit loans to individual farmers or to groups of farmers.

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[26] Even though the organization was created to be directed to women, their clientele constitutes of 62.8% women and 37.2% men.

Even though the loan is extended to the whole group, the loan is handled on an individual basis. Individual farmers who seek credit need to have either a pledge or mortgage collateral (against the idea of microcredit). Group of farmers need to be consolidated as a legal entity and present pledges as collateral to receive loans.

The minimum amount of a loan extended to either an individual or an individual in a group is of L. 1,000. The maximum amount of a loan extended to an individual is L. 100,000; and to an individual as part of a group the maximum is of L. 5,000 (it could go up to L. 20,000 with group credit history).

Crop insurance is not a requirement for obtaining loans because farmers receiving loans would be involved in another activity not related to agriculture.

ODEF charges an annual interest rate of 24%. The strategies ODEF uses to recover the loans include the following: (1) meticulous group selection, (2) financial advisor visits, (3) threat to liquidate collateral, and (4) ask other members to pay for a defaulting member. If payments are late due to an unexpected natural disaster, ODEF extends the repayment period of the loan, although there has not been such a case in the past.

4.2. Farmer Survey

A total of 246 farmers were interviewed in 2007. The farmer survey collected data needed to estimate the stochastic present value of wealth utility model (SPVWUM), including farmers elicited yield distributions, crop production costs, income from other sources, consumption, and farmers' capital assets. Additional data collected included farmers' use of credit and crop insurance, as well as how farmers coped with disaster.

4.2.1. Farmers' elicited yield distributions analysis

The key variable driving the model was intended to be the farmers elicited yield distributions. However, when analyzing these data, some problems with the shape of the distributions became apparent. The following section describes the problem with the yield distribution elicitation.

4.2.1.1. Enumerator bias

The first step after obtaining the farmer data was to generate graphs of the farmer elicited distributions. However, these graphs had unexpected shapes (e.g.,uniform distributions, U shaped, etc.), which led to suspicion of enumerator bias. Therefore, an analysis of variance of the elicited yield distribution was conducted for traditional and modern varieties separately, where the enumerator was entered as a variable. More specifically, the model below (Equation 5) was applied for each type of variety:

$$\mathrm{Pr}\,ob_{ijk} = \mu + Int_i + Vill_j + Enum_k + e_{ijk} \qquad \text{Equation 5}$$

where Prob_{ijk}= probability of interval i, at village j, and enumerator k
μ= mean probability across intervals, villages, and enumerators
Int_i = interval i
Vill_j= village j
Enum_k=Enumerator k
e_{ijk}= error term

Results showed (Tables 58 and 59 (Appendices)) an enumerator effect for modern and traditional varieties. These results indicate enumerator bias (i.e., the shape of the distribution varied by enumerator).

Equation 5 did not control for other factors that could explain the shape of the probability distribution, which is needed to test appropriately if there is an enumerator effect. Therefore, other variables were introduced into the model to control for these other factors that affect the yield probability distribution. The other factors that might affect the yield distribution were hypothesized to be capital, labor, inputs, and managerial techniques. Thus, to control for these factors, the following variables, which serve as proxy variables, were introduced into the model (i.e., Equation 5): type of land preparation system, and type of technology package. Due to the few degrees of freedom, those variables were included in the Equation 5 sequentially.

"Type of land preparation system" was the first variable to be introduced in the analysis of variance of Equation 5 and "type of technology package" followed. Even when additional variables were included in the model (i.e., including the land preparation, or type of technology) the enumerator effect remained (Tables 60 and 61 (Appendices)). To mitigate the enumerator bias effect, farmers' responses from enumerators with the highest percentage of uniform distributions (for beans and corn) were removed from the analysis (Table 14).

After removing the responses of farmers interviewed by enumerator five (i.e., the worst case of bias), the enumerator effect still persisted (Tables 62 and 63 (Appendices)). Only the results for traditional varieties are used in the previous analysis because modern varieties had too few observations for a reliable result. Modern varieties were assumed to have the same results in the analysis of variance as traditional varieties did due to few degrees of freedom; thus only the traditional variety analysis of variance generated a trustful output.

Table 14. Number and percentage of uniform probability distributions that were elicited by enumerators.

Enumerator	# of even distributions	Total # of distributions	% of even distributions
1	0	74	0.0
2	0	48	0.0
3	7	66	10.6
4	0	66	0.0
5	18	83	21.7
6	0	75	0.0
7	0	49	0.0
8	3	16	18.8
9	0	15	0.0
10	3	46	6.5
11	0	8	0.0
12	1	18	5.6
Total	32	564	
Source: Pejuan Bean Farmer Survey, 2007.			

Furthermore, farmers were asked the name of the varieties they grew and to classify them as either a modern or traditional variety. Some farmers wrongly classified the type of variety. The farmers with these mistakes were dropped from the sample because it creates uncertainty when comparing traditional and modern varieties.

4.2.1.2. Incomplete distributions

After partially correcting for enumerator bias (i.e., discarding the responses from enumerator 5), an analysis showed two general forms of farmers' elicited probability distributions: one named *half distribution* (Figure 4) and the other named *more than half distribution* (Figure 5). *Half distribution* was an elicited distribution that showed either a probability density distribution that was increasing or was increasing with a final plateau-like shape without a decreasing section. A *more than half distribution* was an elicited distribution that showed first an increasing and then a decreasing section of the probability density distribution. Other improper types of shapes were excluded from further analysis (e.g., uniform, U shaped).

Figure 4. Half distribution (pdf) classification found in 2007 farmer survey, Honduras 2007.

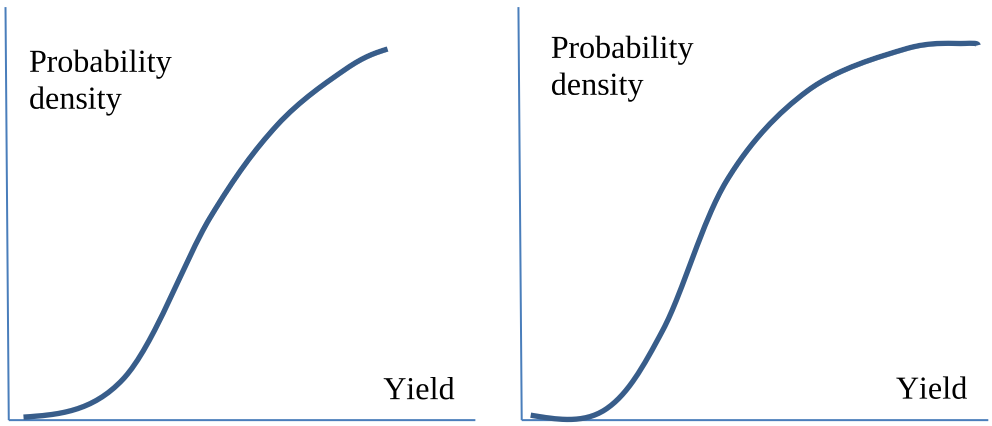
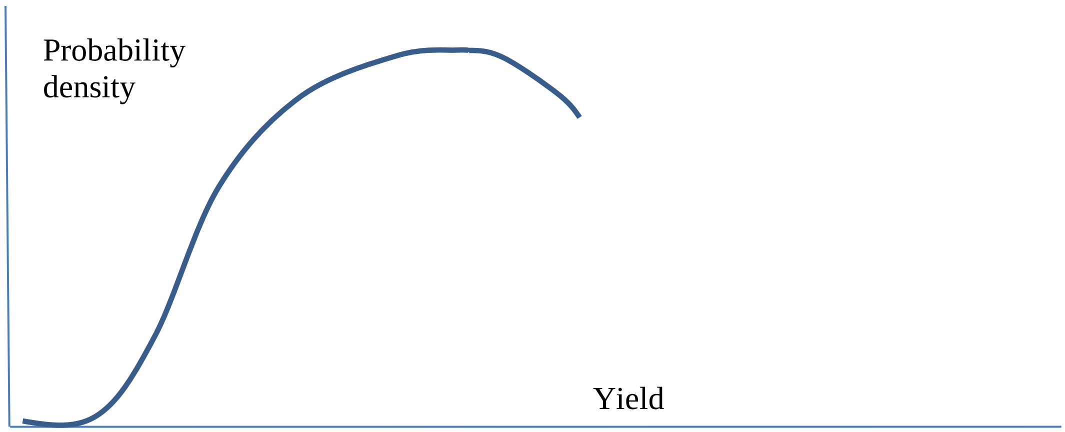


Figure 5. More than half distribution (pdf) classification found in 2007 farmer survey, Honduras 2007.



At this point, it is noted that, few farmers had *half distributions* for both modern and traditional varieties. Similarly, few farmers had *more than half distributions* for both modern and traditional varieties. This situation reduces the power of the comparison analysis, due to the fact that traditional and modern varieties could only be analyzed across farmers instead of within farmers.

It is hypothesized that those farmers with *half* and *more than half distributions* misunderstood the elicitation question and instead of stating the maximum yield, they stated the average or most likely yield.

Several t-tests were performed to evaluate the hypothesis that the *half distributions* resulted from farmers reporting their most likely yield instead of the maximum yield as requested in the questionnaire. Likewise, several t-tests for the *more than half* distributions were performed to test if farmers had in fact understood the question.

The test for *half distribution* compared the maximum, as well as the midpoint of the 5th interval from the elicited distribution, to the farmer self-reported mean. There was no significant difference between the farmers' reported mean and the fifth interval midpoint for the traditional variety *half* distributions, and there was a significant difference from the maximum reported (Table 64 (Appendices)). Similarly, for the *half distribution* of modern varieties, the reported mean was higher than the midpoint of the fifth interval, and there was no significant difference from the maximum reported. These results support the hypothesis that farmers with *half distributions* misunderstood the question and reported maximum yield instead of the most likely yield.

The test for *more than half distributions* compared the 4th and 5th intervals midpoint to the self-reported mean. The modern variety's *more than half* distribution reported mean was significantly different than the fourth interval's midpoint and not different from the fifth interval midpoint and the maximum. Contrary to the hypothesis, for the traditional variety's *more than half* distributions, there were significant differences between the reported mean and the midpoint of the fourth interval, and also to the midpoint of the fifth interval. While some findings do not support the hypothesis, most findings do support the hypothesis that *half* and *more than half* distributions resulted from farmers misunderstanding the question.

4.2.1.3. Villages and farmer categories

The final village groupings and farmer categories (i.e., technology package, and land preparation systems) were created through a sequence of steps. First, villages with similar estimated interval probability parameters and similar in elevation were pooled (Tables 65 and 66 (Appendices)). As a result, the eight sampled villages were reduced to three groups of villages (i.e., Chirinos and Arauli; Talanga and Guaimaca; and Villa de San Francisco and Sabaneta de Valle de Angeles), and two villages that were not pooled (i.e., San Pedro Alauca and La Cienega).

Second, the technology package included four categories: modern varieties with low input use, modern variety with high input use (i.e., modern variety package), traditional varieties with low input use (i.e., traditional variety package), and traditional varieties with high input use. Low and high input use was defined according to the rates of fertilizer. The threshold used to separate low and high rates of fertilizer is 130 kg/ha of the combined amount of all chemical fertilizers used by the bean farmer. This threshold is similar to the rates recommended by Rosas (1996). High input use farmers are those that use amounts of fertilizer greater than or equal to 130 kg/ha of the combination of compound fertilizer (e.g.,12-24-12, 18-46-0, etc.) and urea.

The reason fertilizer was the only criterion used to define the use of input was because most farmers in the sample used insecticides. Since all farmers used insecticides and their application rate depended on the incidence of the pest attack, insecticide use would not provide a meaningful way to define the technology package.

Finally, land preparation method was also used to categorize farmers. Farmers use two types of land preparation system: non-mechanized, and mechanized, which included animal and tractor traction. The non-mechanized category included all households that prepared land with only manual labor. The mechanized category included those households that used oxen and/or tractor. Thus, the combination of the three factors (i.e., land preparation system, type of variety, and input use) result in eight categories, for which seven[27] categories are of interest.

In summary, the model includes seven technology categories of bean farmers for each of the village groupings (i.e., Alauca; Arauli and Chirinos; Talanga and Guaimaca; La Cienega; and Villa de San Francisco and Sabaneta de Valle de Angeles). The seven categories are the following: 1) non-mechanized+traditional variety+low input use (Non-Mech+TV+LoIn); 2) non-mechanized+traditional variety+high input use (Non-Mech+TV+HiIn); 3) non-mechanized+modern variety+low input use (Non-Mech+MV+LoIn); 4) non-mechanized+modern variety+high input use (Non-Mech+MV+HiIn); 5) mechanized+traditional variety+low input use (Mech+TV+LoIn); 6) mechanized+traditional variety+high input use (Mech+TV+HiIn); and,7) mechanized+modern variety+high input use (Mech+MV+HiIn). The certainty equivalents for certain contrasting technology categories (e.g., Non-Mech+TV+LoIn vs. Non-Mech+MV+HiIn) within each village will be compared. Note that these categories only applied to the farmers' bean production since the survey did not collect data on fertilizer use on corn. Thus, corn technology categories only included four categories. The four corn technology categories are: 1) non-mechanized+traditional variety, 2) non-mechanized+modern variety, 3) mechanized+traditional variety, and 4) mechanized+modern variety. However, the SPVWUM assumed yield and corn production costs for all runs to be for traditional corn variety grown at a non-mechanized land preparation system.

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[27] The category mechanized land preparation+modern variety+low input (from a full factorial combination of the three factors) is not included in the model because it is not likely that farmers use this combination.

4.2.1.4. Completing the distributions

Several efforts were done to complete the partial yield distributions (i.e., *half* and *more than half distributions*) obtained from the farmer survey data, and obtain the final shapes of these distributions. These efforts are specified in the Appendices section "Completing the distributions." However, in summary, the *half* and *more than half distributions* were completed using several methods. Completed *half distributions* were not used because these did not provide a sense of skewness. One method used to complete the more than half distributions, out of two methods used, gave as a result, the parameters for an empirical distribution, which would later serve to fit a smoother distribution.

4.2.1.5. Fitted distribution and distribution parameters

Once all elicited probability distributions were completed for each of the farmers with *more than half distributions* within each village, an empirical distribution for each technology level were established. All the parameters were available[28] to estimate the empirical distribution from the completed distributions. A smoother probability distribution was fitted to the empirical distribution and the parameters were obtained.

The Beta distribution gave the best fit to the empirical distribution in terms of Chi-square goodness-of-fit test compared to the Weibull, Pearson, Inverse Gauss, Log Normal, and other distributions. The Beta distribution was then selected over the empirical distribution due to the smoothness properties that it provides for the analysis.

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[28] The minimum, maximum, and probabilities for each interval give shape to an empirical distribution.

The Beta parameters from the fitted Beta distribution to the *more than half distribution* were obtained, however, from only one village, which was the village with several farmers with *more than half distributions*.

Once the Beta distribution parameters (i.e., α, β), which give the distribution its shape, were established, distributions were rescaled[29] for each of the categories using their assumed values of minimum and mean yields,which are discussed on how they were obtained in later sections of this chapter. Other parameters (i.e., coefficient of variation) of the yield probability distributions were examined to observe if these were sensible. It was seen that these distributions did not follow the distributions that were expected in terms of coefficient of variation (CV), so the Beta distribution parameters were finally determined by setting certain restrictions: 1) the distribution needed to have assumed minimum and mean parameters for each technology level discussed in later sections, 2) the parameters have to be as close as possible from the previous Beta parameters obtained, and 3) have a CV of around 30-40% due to estimation of yield CVs with time series data (discussed in later sections). Additionally, all villages kept the same shape parameters.

4.2.1.6. Rescaling

There is a need to rescale because the Beta parameters obtained from fitting the Beta distribution to the empirical distribution would provide a mean and variance parameter in a scale from zero to one. Thus, the rescaling converts the mean and variance parameters from a scale

[29] The Beta distributions need rescaling from its original size, since the original distributions give a sense of shape and relationships of central tendency and variance parameter are in a scale from zero to one.

from zero to one to the actual means and variances assumed for each of the technology categories.

The parameters used to rescale the yield distributions for each of the technology categories are the following: minimum yield values (min), mean yield values (û), and the Beta distribution parameters (α, β). These parameters characterize the whole yield probability distribution. The formula that summarizes the rescaling of the distribution and relationship among these parameters is the following:

$$\hat{u} = \min + (\max - \min)\, \alpha / (\alpha + \beta)$$

To adjust the Beta distribution parameters to fit the central tendency (i.e., mean) and dispersion (i.e., CV) parameters, the assumed minimum and mean values of each distribution were kept constant and the Beta distribution parameters were varied until satisfying the set of restrictions. All maximum values obtained by satisfying the restrictions were in a reasonable range.

As will be noted in the next section, the mean yield values of the bean and corn yield distributions used in the SPVWUM were adjusted from the farmer survey mean values due to general agreement that the yields were lower than normal in that year. In addition, it will be made clear differences between technology levels and villages were obtained from a mix of farmer elicited yield distributions, secondary data, and expert opinion.

4.2.2. Farmer crop revenues and costs

Crop revenues in the SPVWUM were based from the elicited yield distributions, which were later modified, and from a price distribution of corn and beans adjusted to the mean values farmers received at their villages.

The mean yield values from farmer reported yield data of previous years for both corn and beans would have provided a first check on average yields of the elicited yield distributions, if it had been a normal year and if the yield distributions elicitation had generated reasonable shapes. Since neither of these conditions was true, the actual bean and corn yields used in the SPVWUM were based on a combination of information. Differences in yield due to type of variety came from Mather (2003) because there were few observations for modern varieties in the farmer survey. Shape parameters were established as explained previously. Mean yield values were established from secondary information. Yield differences from technology and villages were obtained from primary and secondary information and expert opinion. Differences in yields due to type of land preparation were obtained from differences observed between non-mechanized and mechanized land preparation among the farmers surveyed. Differences in yields due to fertilizer were initially obtained from differences observed between low and high fertilizer use among the farmers surveyed and later were adjusted relying on expert opinion. Differences in yields among villages and minimum yields were based on expert opinion. For the base village (i.e., La Cienega), bean mean yields were based on secondary data and corn mean yields were based on survey yield data.

Production costs for the two crops included in the SPVWUM came from the farmer survey and adjusted for differences between technologies, which are explained in the following section.

4.2.2.1. Corn revenues and costs

Many families that grow beans in Honduras also plant corn (i.e., 300,000 families). This makes it necessary to think the bean farmers' portfolio, as a minimum, include corn.

4.2.2.1.1. Corn yields

Two and a half times as many farmers planted corn in the Primera season compared to the Postrera season. Also, the corn area planted in the Primera, as reported by the National Statistical Institute, was four times the area planted in the Postrera season. Corn yields, as mentioned earlier, were estimated for four technology categories. Farmers' corn yields in the Primera season, for each of the four technology categories, are reported in Table 15. Due to the high right skewness of the data, trimmed means[30] are reported.

Table 15. Trimmed mean corn yields (kg/ha) in Primera by type of land preparation and type of variety.

Category	Trimmed Mean (0.25)	N
Non-mechanized+traditional variety	1,252	30
Non-mechanized+modern variety	1,226	55
Mechanized+traditional variety	1,644	21
Mechanized+modern variety	1,302	36
Total		142
Source: Pejuan Bean Farmer Survey, 2007.		

Table 15 above shows the mean yield of modern and traditional corn varieties under different land preparation systems.

Due to a higher proportion of farmers planting corn in the Primera, it is assumed in the SPVWUM that farmers planted in the Primera. Differences in corn yields due to land preparation system were estimated by regressing corn yields on dummy variables of villages, type of variety, and land preparation system (Table 67 (Appendices)), however, these were not used in the

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[30] A trimmed mean is a mean where a percentage or a proportion (α) of the total number of values is discarded from the smallest and largest observations of the ordered values (Hoaglin *et.al.*, 1983), and the mean is computed from the remaining observations. The proportion selected to discard depends on the tradeoff of robustness and efficiency. As more data is discarded or trimmed, the more robust is the estimate but the efficiency decreases.

SPVWUM because it was assumed only a traditional corn variety was used in the portfolio for all farmers. The difference in corn yield for farms using non-mechanized land preparation versus mechanized land preparation is 152 kg/ha.

To get a sense of the corn yield risk farmers face, the coefficient of variation (CV) of yields of corn was estimated with a time series of corn yields aggregated at the regional level. It resulted in 9% CV. Based on farmers elicited yield distributions and experiences seen at other studies the yield CV was established at 32% for the SPVWUM.

In the SPVWUM, differences among villages in corn yields were based on data provided by expert opinion[31]. Using these data, corn yields were regressed on rainfall[32], elevation above sea level, and level of fertilizer to estimate the coefficients needed to obtain differences in corn yields among villages (Table 68 (Appendices)). The yield differences between all other villages, compared to La Cienega, are presented in Table 16.

Table 16. Corn yield differences (kg/ha) between La Cienega and every other pooled village.

Village	Corn Yield Differences between village and base
Alauca	264
Arauli & Chirinos	238
Guaimaca & Talanga	83
La Cienega	0
Sabaneta & Villa de San Francisco	-7
Source: Pejuan Farmer Survey, 2007.	

Corn yields were not adjusted because the values reported by the sample of farmers were similar to national corn yields and these two crops in the SPVWUM are planted in different seasons. A yield of 1,252 kg/ha (Table 15) was used for yield in the base village, La Cienega.

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[31] Agronomist with 18 years of experience growing or supervising corn and bean plots.
[32] Rainfall square was not included to the corn regression due to the levels of rainfall of the villages are best explained just with the linear coefficient.

4.2.2.1.2. Corn prices

The average price of corn that farmers receive in the Primera harvest period averaged L. 3.98/kg. Similarly to the procedure done to obtain differences among villages, price was regressed on dummy variables for villages and type of variety. As expected, there were no differences between variety types. Nevertheless, only one price was used because of the assumption made of the use of only traditional varieties.

The results from the regression to adjust the corn prices for each village are presented in Table 17. In Table 17, the difference in corn prices reflects how far the village was from a main city. That is, the farther away the village is from a main selling city, the lower the price. Nevertheless, for Alauca, the price is high even though it is close to the department capital. This might actually reflect prices of a net buyer village.

Table 17. Corn prices in Primera by pooled villages.

Villages	**Price (L. /kg)**
Alauca	5.08
Arauli and Chirinos	3.73
Talanga and Guaimaca	5.44
La Cienega	4.91
Villa de San Francisco and Sabaneta de Valle de Angeles	4.54
Source: Pejuan Farmer Survey, 2007.	

To get a sense of the corn price risk farmers face, the coefficient of variation (CV) of prices of corn was estimated with a time series of corn prices at a market in the capital city of Tegucigalpa. It resulted in 16% CV. It was then adjusted up to 20% due to differences from the market level and at the farm level, and because of experiences in other studies.

Corn prices used in the SPVWUM are based on mean selling prices farmers obtained in each of the villages. Also, the price distribution used in the SPVWUM assumed a log-normal distribution with the previously estimated 20% coefficient of variation. Corn and traditional and modern bean price variety correlations were obtained from historical price Honduran

Agricultural Product Information System ("Sistema de Información de Mercados de Productos Agricolas de *Honduras" (SIMPAH))*. Correlation was estimated at 0.52 and 0.45, respectively.

4.2.2.1.3. Corn production costs

Corn production costs (mean) for each of the four corn farmer categories are presented in Table 18. These costs are cash expenses, so that the return on corn is return to family labor, land, and management; this is also gross income (i.e., revenue minus variable costs (except for family labor in this study)).

Table 18. Trimmed mean corn costs (L./ha) in Primera by type of land preparation and type of variety.

Category	Trimmed Mean (0.25)	N
Non-mechanized+traditional variety	5,303	30
Non-mechanized+modern variety	4,791	55
Mechanized+traditional variety	6,115	21
Mechanized+modern variety	7,067	35
Total		141
Source: Pejuan Farmer Survey, 2007.		

Since all of the SPVWUM scenarios assumed that farmers planted a traditional corn variety, the corresponding yield, as well as the costs of growing a traditional variety, is used in the model. The corn production costs used in SPVWUM consist of a base cost, which is 77% of the cost of non-mechanized land preparation+traditional variety category (Table 18), plus a yield adjusted cost which depends on the yield. The 77% is approximately the percentage of cost which is incurred during the first month after planting. Thus, if a farmer observes a bad season and decides not to use the usual amount of inputs, he/she has already incurred 77% of the production costs. Additionally, harvesting costs dependent on yields are included in the model.

4.2.2.2. Bean revenues and costs

4.2.2.2.1. Bean yields

Contrary to corn, two and a half times as many farmers planted beans in the Postrera compared to the Primera. Also, the bean area planted in the Postrera, as reported by the National Statistical Institute (INE), is more than twice the area planted in the Primera season. Farmers' bean trimmed mean yields by land preparation system, type of variety, and technology level are shown in Table 19.

Table 19. Trimmed mean bean yields (kg/ha) by type of land preparation, type of variety and technology applied.

Category	Trimmed Mean (0.25)	N
Non-mechanized+traditional variety+low input use	380	36
Non-mechanized+traditional variety+high input use	654	60
Non-mechanized+modern variety+low input use	241	8
Non-mechanized+modern variety+high input use	682	4
Mechanized+traditional variety+low input use	321	52
Mechanized+traditional variety+high input use	537	27
Mechanized+modern variety+low input use	130	3
Mechanized+modern variety+high input use	931	6
Total		196
Source: Pejuan Bean Farmer Survey, 2007.		

Table 19 above was mostly used to estimate the response of traditional bean varieties to fertilizer levels under different land preparation systems. However, for modern varieties, there are too few observations to make a similar inference.

The yields of modern and traditional bean varieties given above are for informational purposes only. Given that there is insufficient data on yields for modern bean varieties and that the national bean yield is above those values, it was necessary to use secondary data to adjust those values for the simulations.

To get a sense of the bean yield risk farmers face, the coefficient of variation (CV) of yields of bean was estimated with a time series of bean yields aggregated at the regional level. It resulted in 14% CV. Based on farmers elicited yield distributions and experiences seen at other studies the yield CV was established at a range from 32% to 34% for the SPVWUM depending on the technology.

Due to a higher proportion of farmers planting beans in the Postrera, in the SPVWUM, it was assumed that farmers planted in the Postrera. As it was done for corn, differences in bean yields due to land preparation system were estimated by regressing bean yields on dummy variables for villages, type of variety, and land preparation system (Table 67 (Appendices)). This analysis showed a difference in bean yield between non-mechanized land preparation and mechanized land preparation to be 65 kg/ha.

Bean yield differences between modern and traditional varieties are not captured well by the farmer survey, since few farmers planted modern varieties. Mather (2003) reported a 28% difference between modern and traditional varieties which translates to a 200 kg/ha difference when using the national average bean yield for the Postrera season (i.e., 713 kg/ha * 0.28 = 200 kg/ha).

Yield differences due to low and high fertilizer levels were adjusted from a 172 kg/ha (i.e., Table 67 (Appendices)) to a 200 kg/ha difference. This adjustment was made due to expert opinion expressing that bean yields normally respond to fertilizer in a one-to-one ratio (i.e., the fertilizer use difference between low and high fertilizer was 200 kg/ha).

For the SPVWUM, differences in bean yields among villages were obtained, like in corn, from data provided by experts. Using these data, bean yields were regressed on rainfall, as well as rainfall squared, elevation above sea level, and level of fertilizer. This analysis provided the coefficients needed to estimate differences in bean yields among villages (Table 68

(Appendices)). Table 20 presents bean yield differences between all other villages, compared to La Cienega.

Table 20. Bean yield differences (kg/ha) between La Cienega and other villages.

Village	Bean Yield Differences between village and base
Alauca	-17
Arauli & Chirinos	-3
Guaimaca & Talanga	190
La Cienega (base)	0
Sabaneta & Villa de San Francisco	36
Source: Pejuan Farmer Survey, 2007.	

It was assumed that the yield in the base village La Cienega for a non-mechanized+traditional variety+low input farmer (i.e., 856 kg/ha) was 20% above the national average yield for the Postrera season (i.e., 713 kg/ha, Table 21). As mentioned before, this 20% yield adjustment is justified because these villages are more specialized in beans than the average village in Honduras. The mean yields in the other villages were estimated by adding the yield differences between these villages and village La Cienega (Table 20) to the latter village assumed yield. La Cienega was selected as the base village because the average elevation and precipitation in these villages in El Paraiso and Francisco Morazan departments matches this village--making it a representative village for these departments.

Table 21. Average national bean yields (kg/ha) for period 1990-2007.

Crop	Season	Yield	N
Beans	Primera	630	18
Beans	Postrera	713	18
Source: Honduras. Instituto Nacional de Estadistica (INE), Encuesta Agropecuaria Básica, May 2007.			

The minimum yields used in the SPVWUM for each of the technology categories represent the riskiness from a bad event. A lower minimum yield represents a riskier technology category. Table 22 presents the expected minimum yields for different bean categories.

Table 22. Expected minimum bean yields by category.

Category	Average Minimum kg/ha
Non-mechanized+traditional variety+low input use	145
Non-mechanized+traditional variety+high input use	130
Non-mechanized+modern variety+low input use	15
Non-mechanized+modern variety+high input use	10
Mechanized+traditional variety+low input use	140
Mechanized+traditional variety+high input use	130
Mechanized+modern variety+low input use	10
Mechanized+modern variety+high input use	5
Source: Pejuan Bean Farmer Survey, 2007 and expert opinion.	

The expected minimum values (kg/ha) and differences among these minimum values in each of the technology categories were made from judgment based on minimum yields from the farmer survey, assumptions from literature, and from expert opinion. Low yields are usually due to drought and therefore the expected differences among technologies rely mostly on precipitation.

Up until recent years, a traditional bean variety was expected to have a higher minimum yield than a modern variety because of its higher drought tolerance. With the release of new modern varieties, this is no longer the case. Nevertheless, farmers might not be aware of this and still think the distribution of the modern varieties has a thicker lower tail. Table 22 assumes that farmers still perceive that a modern variety has a lower minimum yield vis-à-vis traditional varieties. It also assumes that at a high fertilization level, the minimum yield is lower than at the low fertilization level. This is due to the combination of low precipitation and a high fertilizer level which might burn the plant and result in lower yields. During drought, high fertilizer increases the likelihood of chemical damage to the plant resulting in lower yields.

Additionally, non-mechanized preparation of the land leaves more mulch on the ground than does mechanized land preparation, which helps maintain moisture in the soil and therefore result in higher minimum yields.

However, for runs of the SPVWUM in @Risk, the actual minimum yield values used were lower than those in Table 22. The minimum yield values set to run @Risk where not only lower than those in Table 22, but many were even negative so that the actual minimum outcomes from simulation runs, would result in the minimum values from Table 22[33]. These values will be presented in the parameters section at the end of this chapter. This practice might be unorthodox, however, this is a practice done by simulators when values resulting from the simulation are not close to the values set for the distribution.

4.2.2.2.2. Bean prices

Similar to corn, bean prices were regressed on dummy variables for villages and on type of variety. However, only the mean prices for the traditional variety in each village were taken and the differences among villages were adjusted. The bean prices for each village are presented in Table 23.

Table 23. Bean prices (L. / kg) in Postrera by pooled villages and type of variety.

	Type of Variety	
Villages	**Traditional**	**Modern***
Alauca	11.00	9.90
Arauli and Chirinos	10.24	9.22
Talanga and Guaimaca	10.72	9.65
La Cienega	12.99	11.69
Villa de San Francisco and Sabaneta de Valle de Angeles	11.17	10.05

*Modern variety prices are 10% lower than traditional varieties
Source: Pejuan Bean Farmer Survey, 2007.

As was the case for corn prices, there were no differences found between variety types. However, this is because of the few observations for the price of modern varieties and their high

[33] Since the minimum yield values observed from the preliminary runs in @Risk where much higher than the values in Table 22, the minimum yield values were then reduced until they matched the values in Table 22. This reduction lead to negative minimum points for minimum yields but no actual negative values for yields because of truncation of yields at zero: Yield used in simulation=max(yield from random number generator , 0).

variance. Since price differentials between modern and traditional bean varieties have been well documented (Martel, 1996; Mather, 2003; Pejuan, 2005), a 10% price difference was assumed for the SPVWUM (Table 23).

Also, the bean price distribution used in the SPVWUM assumed a log-normal distribution and a 20% coefficient of variation.

To get a sense of the bean price risk farmers face, the coefficient of variation (CV) of prices of beans was estimated with a time series of bean prices at a market in the capital city of Tegucigalpa. It resulted in 19% CV. It was then adjusted up to 20% due to differences from the market level and at the farm level, and because of experiences in other studies.

4.2.2.2.3. Bean costs

Bean production costs are also part of the SPVWUM. These costs are subtracted from revenues to obtain returns to family labor, land, capital, and management defined in this study as gross income. Bean costs in the farmer survey are divided into input costs and activity expenditure costs. Activity expenditure costs included costs of machinery used.

The general treatment of information obtained on inputs from the farmer survey was as follows. If the price of the input was missing, it was replaced with the mean price of the input in the villages or of a closely related input. Out of 1,077 observations, a total of 68 mean prices were introduced. Also, input physical quantity outliers were replaced with frontier values (i.e., three standard deviations from the mean of each input value). Outliers were defined as unlikely values that, probably, were either due to a misunderstanding of a question or a data entry error.

4.2.2.2.4. Input use and costs

Bean inputs include seed, fertilizer, herbicide, fungicide, insecticide and other pesticides. The inputs farmers used across the study areas varied greatly. Farmers mentioned 19 different bean varieties (Table 24). Also, farmers used 9 different types of fertilizer, 16 brands of herbicide, 11 brands of insecticide, and 9 brands of fungicide. Within the brands farmers used different formulations of the product. The different bean varieties used by farmers, as well as most commonly used brands of pesticides, are presented in the following sections.

4.2.2.2.5. Varieties and seeding rate

Farmers used a diversity of bean varieties (Table 24). Nevertheless, only a few were widely used in most villages. The overall mean seed rate was 42kg/ha.

Table 24. Bean varieties* used by farmers, Honduras 2007.

Variety Name	
Amadeus**	Re Tinto***
Tio Canela**	Renegrido***
Arbolito***	Rosita***
Catracho****	Rural****
Chato***	Tinto***
Cuarenteño***	Vaina Blanca***
Danli****	Vaina Roja ***
Marciano**	Vaina Rosada ***
Paraisito***	Zamorano****
Payomo***	
*Some varieties may have the same genetic profile but a different name. **Modern variety ***Traditional variety ****Improved variety released before 1990, thus classified as a traditional variety.	

4.2.2.2.6. Fertilizer use

Farmers used mainly compound fertilizer. That is, they used types of fertilizer that would provide at least two of the major nutrients (i.e., N, P, K). In addition, a few farmers used organic matter and/or foliar fertilizer. The compound fertilizers types farmers used are presented in Table 25, together with urea. The most popular fertilizer formula is 12-24-12-- 42% of farmers applied it at an average rate of 142 kg/ha and paid an average price of L. 7.44/kg. The second most popular fertilizer was 18-46-0-- 30% of farmers applied it at an average rate of 102 kg/ha and paid an average price of L. 8.00/kg. The third most popular fertilizer was urea-- 5% of farmers applied it at a rate of 78 kg/ha and paid an average price of L. 6.98/kg. Some farmers used more than one type of fertilizer (e.g., 12-24-12 and urea).

Table 25. Fertilizer used by farmers, Honduras 2007.

Fertilizer formula
12-24-12
18-46-0
Urea (45-0-0)
20-20-20
15-15-15
Source: Pejuan Bean Farmer Survey, 2007.

4.2.2.2.7. Herbicide use

Herbicide is widely used by farmers. The herbicides farmers used are presented in Table 26. The most popular herbicide was Gramoxone-- 69% of farmers applied it at an average rate of 3.73 l/ha and paid an average price of L. 98.74/l. The second most popular herbicide was Fusilade-- 13% of farmers applied it at an average rate of 1.24 l/ha and paid an average price of L. 422/l. The third most popular herbicide was 2-4,D-- 5% of farmers applied it at a rate of 1.93 l/ha and paid an average price of L. 88/l. The fourth most popular herbicide was Glyphosate--3% of farmers applied it at a rate of 2.57 l/ha and paid an average price of L. 136/l. Some farmers used more than one type of herbicide (i.e., Gramoxone and 2-4,D).

4.2.2.2.8. Fungicide use

Fungicide is used by a small percentage of farmers. The fungicides farmers used are presented in Table 27. The most popular fungicide was Dithane-- 8% of farmers applied it at an average rate of 2.07kg/ha and paid an average price of L. 131/kg. The second most popular fungicide was Antracol-- 6% of farmers applied it at an average rate of 0.8 kg/ha and paid an average price of L. 158/kg.

Table 26. Herbicides used by farmers, Honduras 2007.

Gramoxone	Rimax
Bayta	Basagran
Fusilade	Flin
Glyphosate	Basta
Rodoy	Remaxato
Boa	Riandi
Flet	Gesaprin
2-4 D	Rescate
Source: Pejuan Bean Farmer Survey, 2007.	

Table 27. Fungicides used by farmers, Honduras 2007.

Dithane	Curatan
Antracol	Bravo
Mancozeb	Bayfolan
Aeroback	Batalla
Manzate	
Source: Pejuan Bean Farmer survey, 2007.	

4.2.2.2.9. Insecticide use

Insecticide is as widely used as herbicide is. The insecticides farmers use are presented in Table 28. The most popular insecticide was Folidol-- 34% of farmers applied it at an average rate of 1.4 l/ha and paid an average price of L. 168/l. The second most popular insecticide was Thiodan-- 14% of farmers applied it at an average rate of 1.41 l/ha and paid an average price of L. 174/l. The third most popular insecticide was Tamaron-- 12% of farmers applied it at a rate of 1.30 l/ha and paid an average price of L. 199/l. Several farmers use more than one type of insecticide in the growing season.

Table 28. Insecticides used by farmers, Honduras 2007.

Insecticide	Insecticide
Folidol	Pirineta
Thiodan	Cipermetrina
Tamaron	Karate
Monarca	Muralla
Tambo	Decis
Source: Pejuan Bean Farmer Survey, 2007.	

4.2.2.2.10. Input expenditures

Input expenditures (L./ha) for each of the eight technology categories or choices are presented in Table 29. Input expenditures for non-mechanized land preparation were, unexpectedly, larger compared to mechanized land preparation system (Table 29). The differences in input expenditures between the non-mechanized and mechanized land preparation systems can be explained because of the difference in area between types of farmers (i.e., mechanized farms were generally larger), which is sometimes observed in empirical research. Also, farmers using the non-mechanized land preparation system and traditional varieties with high inputs have greater input expenditures than those using non-mechanized land preparation system with the modern package. This result is not reliable due to few observations for farmers using modern varieties. Thus, the input expenditure values for the modern variety categories were modified for inclusion in the SPVWUM. This modification used the traditional variety as a base, then the additional cost of the seed, and harvesting costs were included.

Table 29. Trimmed mean input expenditures (L./ha) by type of land preparation, type of variety and technology applied.

Category	Trimmed Mean (0.25)	N
Non-mechanized+traditional variety+low input use	1,466	36
Non-mechanized+traditional variety+high input use	3,475	60
Non-mechanized+modern variety+low input use	1,390	8
Non-mechanized+modern variety+high input use	2,744	4
Mechanized+traditional variety+low input use	1,399	53
Mechanized+traditional variety+high input use	2,649	28
Mechanized+modern variety+low input use	1,491	3
Mechanized+modern variety+high input use	2,262	6
	Total	198
Source: Pejuan Bean Farmer Survey, 2007.		

It is sometimes observed that farmers with larger areas of crop land use fewer inputs per hectare compared to those who have smaller farms because of economies of scale or just because they are being more efficient. To observe if higher input expenditures are related to area in the survey data, input expenditures were regressed on area planted to bean by type of land preparation system. The results show that farmers with less land have higher input expenditures per hectare, probably because of unnecessary use of inputs.

A higher cost is expected for the modern variety category due to the higher price of a modern seed variety. Thus, the modern variety input expenditure categories used the traditional input expenditure cost as a base in the SPVWUM, added an annualized cost of modern seed[34] and reduced the cost of fungicides due to higher disease resistance of modern varieties.

4.2.2.2.11. Partial budgets for variety change in each village

Table 3 in Chapter 2 showed a general partial budget analysis for the change in variety. This showed that, in general, the change was profitable. However, prices and yields change across the villages and it is important to see if the change in variety in each village is profitable, assuming the prices, yields, and costs estimated for each village. The net change per hectare by the change in variety from a traditional variety to a modern variety for La Cienega, Talanga and Guaimaca, Arauli and Chirinos, Villa de San Francisco and Sabaneta de Valle de Angeles, and Alauca are L. 741, L. 286, L. 442, L. 495, and L. 537, respectively (Tables 69 through 73 in Appendices). Change in variety is profitable in each village.

4.2.2.2.12. Activity expenditures

Activity expenditures included labor expenditures and mechanized activities. Labor expenditures included manual labor for land preparation, planting, fertilizing, applying pesticides, harvesting, threshing, and transportation of harvest. Mechanized activities include mechanized plowing, planting, and threshing. As mentioned before, expenditures only include cash costs, so

[34] Farmers use saved-grain as seed for several growing seasons.

family labor is not included. Thus, gross income is returns to capital, family labor, land, and management. Activity expenditures, in this setting of returns to capital, family labor, land, and management, can also be called residual activity expenditures. Farmers' residual activity expenditures are shown in Table 30.

Table 30. Trimmed mean residual activity expenditures (L./ha) by type of land preparation, type of variety and technology applied.

Category	Trimmed Mean (0.25)	N
Non-mechanized+traditional variety+low input use	4,077	36
Non-mechanized+traditional variety+high input use	4,027	60
Non-mechanized+modern variety+low input use	2,178	8
Non-mechanized+modern variety+high input use	7,487	4
Mechanized+traditional variety+low input use	3,535	53
Mechanized+traditional variety+high input use	4,306	28
Mechanized+modern variety+low input use	4,723	3
Mechanized+modern variety+high input use	4,213	6
	Total	198
Source: Pejuan Bean Farmer Survey, 2007.		

Residual activity expenditures were lower for the mechanized land preparation system compared to the non-mechanized land preparation system, given that a traditional variety and low inputs were used. Conversely, residual activity expenditures were higher for the mechanized land preparation system compared to non-mechanized land preparation system, given that a traditional variety and high inputs were used. These higher expenditures for the mechanized land preparation system is due to a higher proportion of cash to non-cash expenditures for the mechanized land preparation system, compared to the non-mechanized land preparation system.

Residual activity expenditures were added to the input expenditures to obtain the total residual expenditures. Similar to corn, 77% of the total residual expenditures were used as a base expenditure and then a yield adjusted cost is added to the total residual expenditures.

The total residual expenditures are subtracted from bean revenues to obtain gross income (i.e., return to capital, family labor, land, and management).

4.2.2.2.13. Area planted to beans and corn

In the SPVWUM, the area planted to bean and corn is assumed to be the same, given that they are planted in different seasons. The area used in the SPVWUM is 1.9 hectares.

4.2.3. Gross income from other sources

Farmers have other sources of income in addition to the corn and bean revenue presented before. Farmers engage in off-farm labor, plant other crops, and have other small businesses, and net remittances. During the survey, farmers' estimates of these gross income sources were collected for the previous year and used to contribute (i.e., gross income from crop production is also needed) to estimating the marginal wealth for all years (i.e., it was assumed that all income from other sources was kept constant through the years).

In theory, net income should equal consumption expenditures. However, in all villages there was a gap between total gross income--income from other sources added to mean gross income from crop production—and consumption expenditures (i.e., consumption expenditures were larger than gross income), probably because some farmers failed to report income from other sources.

To address this problem, data for consumption, as well as data for gross income from other sources, were pooled across villages with similar values for consumption and gross income from other sources. These pooling created three groups of villages. After pooling, the gross income from other sources for Alauca; Arauli and Chirinos, Talanga and Guaimaca; and Villa de San Francisco and Sabaneta are L. 5,718; L. 10,478; and L. 20,039, respectively. Pooling did not solve the problem of the gap. Due to this, gross income from other sources was adjusted to fill the gap between gross income and consumption expenditures. The gap was filled by taking the gross mean income approximately 3% above the consumption expenditure level across the villages.

4.2.3.1. Remittances

While net remittances are already included in the income from other sources section, it is important to note that remittances were received by just a few farmers in each village. However, the mean values were considerably high. While no farmers in Alauca received positive net remittances, for Arauli and Chirinos, Talanga and Guaimaca, and La Cienega mean net remittances were L. 24,698 (N=18). Villa de San Francisco and Sabaneta de Valle de Angeles had a mean net remittance of L. 25,500 (N=7). Most of the farmers who received remittances were in the mechanized land preparation+traditional variety+high fertilizer category (N=11).

4.2.4. Consumption

As previously described, consumption data were pooled similarly to the gross income from other sources. Farmers' food, clothing, and education expenditures for Alauca; Arauli and Chirinos, Talanga and Guaimaca; and Villa de San Francisco and Sabaneta were L. 19,350; L. 31,845, and L. 32,517, respectively.

4.2.5. Farmer assets

Farmers' assets will account for the farmers' initial wealth. In later years, changes in wealth will be observed and computed for the SPVWUM. Farmers´ assets included land, infrastructure, machinery, and farm animals. Farmers' value of capital assets is shown in Table 31.

Table 31. Trimmed mean value (L.) of farmers' capital assets by type of land preparation, type of variety and technology applied.

Category	Trimmed Mean (0.25)	N
Non-mechanized+traditional variety+low input use	108,325	36
Non-mechanized+traditional variety+high input use	139,467	60
Non-mechanized+modern variety+low input use	76,775	8
Non-mechanized+modern variety+high input use	65,995	4
Mechanized+traditional variety+low input use	182,564	53
Mechanized+traditional variety+high input use	293,966	28
Mechanized+modern variety+low input use	376,536	3
Mechanized+modern variety+high input use	504,100	6
Source: Pejuan Bean Farmer Survey, 2007.		

4.2.6. Farmer use of credit

At one point in time during the 2001 to 2006 period, 40% of the farmers (N=193) obtained credit from a formal institution (bank, rural cashier, NGO). The other 60% of the farmers reported several reasons for not obtaining credit including the following: disliking borrowing (42%), not having collateral (17%), banks denying credit (13%), risk of losing collateral (12%), having alternative lenders, having high interest rates, and it being a burdensome process.

Seventy-three percent of the farmers who did not borrow had not heard of crop insurance. All farmers who did not borrow also did not buy crop insurance. From those who did borrow, 79% had heard of crop insurance. Sixty-eight percent of those who borrowed bought crop insurance.

4.2.7. Farmer use of crop insurance

Farmers who had bought crop insurance accounted for about one-fifth of the sample (i.e., after removing the observations by enumerator 5 and farmers confusing traditional and modern varieties). Farmer awareness and use of crop insurance is shown in Table 32. This shows that a high percentage (i.e., 50%) of farmers still is not aware of a service available like crop insurance.

Table 32. Farmer awareness and use of crop insurance.

Heard of crop insurance** ?	Number of farmers	
	Ever bought crop insurance* ?	
	No	Yes
No	99	0
Yes	50	42

* Five missing values.
** Three missing values.
Source: Pejuan Bean Farmer Survey, 2007.

Farmers who actually bought crop insurance, reported several reasons why they purchased it (Table 33). The majority reported some version of the desire to insure their investment. However, more than a third bought it because it was bundled with the loan. Farmers who had heard of crop insurance, but had not bought it reported several reasons why they had not bought crop insurance (Table 34). The main reason was "not knowing how crop insurance works."

Table 33. Percent of farmers quoting different reasons for buying bean insurance.

Reason for buying bean insurance	(%)*
Bundled with loan	37.5
For indemnization	42.5
To automatically repay loan in case of crop loss	7.5
For indemnity and automatic repay of loan in case of crop loss	5
To insure investment	7.5

* Two missing values; N=40
Source: Pejuan Bean Farmer Survey, 2007.

Table 34. Percent of farmers quoting different reasons for not buying bean insurance.

Reason for buying bean insurance	(%)*
Lacking money	18
Not interested	32
Does not know the procedure/benefits of bean insurance	44
Just crops a small area	3
I have not obtained a loan	3

* 16 missing values/non responses; N=34

4.2.8. Coverages in Honduras

In Honduras, the insurance coverages, which are the liability amounts (i.e., reimbursement to the farmer in case of total loss) as a percentage of the mean yield, are approximately 43%. This coverage was estimated by: 1) dividing the liability (i.e., L. 5,000/ha) by the indemnity price (i.e., L8.87/kg), which results in the insured amount of beans (in kg/ha), and 2) dividing the insured amount of beans (in kg/ha) by the average yield (i.e., 1,319 kg/ha, assuming the insurance contract is offered to a farmer using the modern variety package and who uses the mechanized land preparation system). The coverage level offered is low. However, Honduran crop insurance services are new and most insurance coverages in developed countries started at low levels. The low levels are to insure an amount approximately equal to bean farmers working capital, which is to assure farmers would be able to grow a new crop in case of a bad event happening.

The SPVWUM uses coverage of both 45% and 75%. The latter coverage is a standard U.S. coverage. The latter coverage is also used to observe if an improvement in the coverage level will induce farmers to adopt modern varieties.

Given those coverages, the loading factors[35] where unusually high (i.e., 3 to 5 depending on the technology category). Thus, a more reasonable loading factor (i.e., 1.4) was used for the SPVWUM. This loading factor was used to observe if an improvement in the crop insurance contract would encourage farmers to adopt the modern variety package.

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[35] The loading factor multiplies the actuarially fair premium (i.e., the premium equal to the expected losses) and the product of the multiplication is the actual premium paid by the farmer.

4.2.9. Farmer coping with disaster

Forty percent of the farmers reported that they had never experienced a production level low enough to not be able to cover the years' worth of normal expenses (food, clothing, education). The farmers who suffered an extreme shortage experienced it with different frequency (Table 35).

Table 35. Farmers experiencing shortage of income different percent of time.

Percent of time experiencing shortages	Number of farmers	Cumulative Percent
Less than or equal to 20%	48	42
Greater than 20% and less than or equal to 40%	32	70
Greater than 40% and less than or equal to 60%	22	87
Greater than 60% and less than or equal to 80%	10	97
Greater than 80%	3	100

*2 missing values/non responses; N=115
Source: Pejuan Bean Farmer Survey, 2007.

The 60% of farmers that have experienced shortcomes need to deal with the effects of perils and have different ways of coping with its shocks that impact their incomes. Farmers cope with income shortages by mainly relying in working in another job besides their crop enterprise (50%), selling their assets (24%), and asking for a loan from friends, family or other person (14%) (Table 74 in Appendices).

4.3. Parameters used for simulation

Table 4 in Chapter 3 showed the different technology categories or choices that the farmer could make. The sequence followed in making certainty equivalents comparisons is important according to the question to be answered. The following section presents a summary of the parameters used in the SPVWUM that are associated with different technologies (i.e., type of variety, amount of fertilizer applied, land preparation system), level of yields, prices, and costs, as well as the levels of wealth, consumption, and income from other sources for each village. For this summary of the parameters used for the SPVWUM, it is necessary to note that the certainty equivalents (as shown in Table 4) that will be computed for the five villages, will have values for two levels of coverage (i.e., 45% and 75%), two rates of time preference (i.e., discount rate) levels (i.e., 7% and 14%), and two loading factors (i.e., 1.0 and 1.4). The summary of parameters used to run the SPVWUM for each of the villages are presented in Tables 36 to 40.

Many of the parameters are constant across several categories in each run of the SPVWUM, in order to be able to make leveled comparisons and observe if a change in just one aspect of the technology would make a difference to the farmer, or if a change of technology in a bundle would make a difference. This way, confounding effects are avoided.

Table 36. Parameters* used in @Risk for the stochastic present value of wealth utility model for Alauca farmers, Honduras.

Parameter across technology categories	Technology category						
	NMTVLI	NMTVHI	NMMVLI	NMMVHI	MTVLI	MTVHI	MMVHI
Bean mean yield value (kg/ha)	839	1,039	1,039	1,239	903	1,103	1,303
Bean price (L./kg)	11.00	11.00	9.90	9.90	11.00	11.00	9.90
Bean price standard deviation	2.20	2.20	1.98	1.98	2.20	2.20	1.98
Bean minimum yield value (kg/ha)	70	20	-72	-125	66	20	-172
Bean base cost (L./ha)	4,269	5,777	4,558	6,065	3,800	5,356	5,644
Corn mean yield value (kg/ha)	1,516	1,516	1,516	1,516	1,516	1,516	1,516
Corn price (L./kg)	5.08	5.08	5.08	5.08	5.08	5.08	5.08
Corn price standard deviation	1.02	1.02	1.02	1.02	1.02	1.02	1.02
Consumption (L.)	21,314	21,314	21,314	21,314	21,314	21,314	21,314
Income from other sources (L.)	11,218	11,218	11,218	11,218	11,218	11,218	11,218
Corn minimum yield value (kg/ha)	45	45	45	45	45	45	45
Corn base cost (L./ha)	4,083	4,083	4,083	4,083	4,083	4,083	4,083
Initial wealth (L.)	108,325	108,325	108,325	108,325	108,325	108,325	108,325
Bean and corn area (ha)	1.9	1.9	1.9	1.9	1.9	1.9	1.9
Bean and corn alpha distribution	5.08	5.08	5.08	5.08	5.08	5.08	5.08
Bean and corn beta distribution	4.50	4.50	4.50	4.50	4.50	4.50	4.50
House value (L.)	43,690	43,690	43,690	43,690	43,690	43,690	43,690

*For each technology category and village, two discount rates (i.e., 0.07 and 0.14) and two coefficients of relative risk aversion (i.e., 2 and 4) were applied. For those choices that include insurance, two loading factors (i.e., 1 and 1.4) and two coverage levels (i.e., 0.45 and 0.75) were used. The bank semi-annual interest rate used was of 0.08. NMTVLI= Non-Mech+TV+LoIn; NMTVHI= Non-Mech+TV+HiIn; NMMVLI= Non-Mech+MV+LoIn; NMMVHI= Non-Mech+MV+HiIn; MTVLI=Mech+TV+LoIn; MTVHI=Mech+TV+HiIn; MMVLI=Mech+MV+LoIn; MMVHI=Mech+MV+HiIn

Table 37. Parameters* used in @Risk for the stochastic present value of wealth utility model for Arauli and Chirinos farmers, Honduras.

Parameter across technology categories	Technology category						
	NMTVLI	**NMTVHI**	**NMMVLI**	**NMMVHI**	**MTVLI**	**MTVHI**	**MMVHI**
Bean mean yield value (kg/ha)	851	1,051	1,051	1,251	917	1,117	1,317
Bean price (L./kg)	10.24	10.24	9.22	9.22	10.24	10.24	9.22
Bean price standard deviation	2.05	2.05	1.84	1.84	2.05	2.05	1.84
Bean minimum yield value (kg/ha)	70	20	-72	-125	66	20	-172
Bean base cost (L./ha)	4,269	5,777	4,558	6,065	3,800	5,356	5,644
Corn mean yield value (kg/ha)	1,490	1,490	1,490	1,490	1,490	1,490	1,490
Corn price (L./kg)	3.73	3.73	3.73	3.73	3.73	3.73	3.73
Corn price standard deviation	0.75	0.75	0.75	0.75	0.75	0.75	0.75
Consumption (L.)	34,019	34,019	34,019	34,019	34,019	34,019	34,019
Income from other sources (L.)	27,978	27,978	27,978	27,978	27,978	27,978	27,978
Corn minimum yield value (kg/ha)	45	45	45	45	45	45	45
Corn base cost (L./ha)	4,083	4,083	4,083	4,083	4,083	4,083	4,083
Initial wealth (L.)	108,325	108,325	108,325	108,325	108,325	108,325	108,325
Bean and corn area (ha)	1.9	1.9	1.9	1.9	1.9	1.9	1.9
Bean and corn alpha distribution	5.08	5.08	5.08	5.08	5.08	5.08	5.08
Bean and corn beta distribution	4.50	4.50	4.50	4.50	4.50	4.50	4.50
House value (L.)	43,690	43,690	43,690	43,690	43,690	43,690	43,690

*For each technology category and village, two discount rates (i.e., 0.07 and 0.14) and two coefficients of relative risk aversion (i.e., 2 and 4) were applied. For those choices that include insurance, two loading factors (i.e., 1 and 1.4) and two coverage levels (i.e., 0.45 and 0.75) were used. The bank semi-annual interest rate used was of 0.08. NMTVLI= Non-Mech+TV+LoIn; NMTVHI= Non-Mech+TV+HiIn; NMMVLI= Non-Mech+MV+LoIn; NMMVHI= Non-Mech+MV+HiIn; MTVLI=Mech+TV+LoIn; MTVHI=Mech+TV+HiIn; MMVLI=Mech+MV+LoIn; MMVHI=Mech+MV+HiIn

Table 38. Parameters* used in @Risk for the stochastic present value of wealth utility model for Talanga and Guaimaca farmers, Honduras.

Parameter across technology categories	Technology category						
	NMTVLI	**NMTVHI**	**NMMVLI**	**NMMVHI**	**MTVLI**	**MTVHI**	**MMVHI**
Bean mean yield value (kg/ha)	1,046	1,246	1,246	1,446	1,109	1,309	1,509
Bean price (L./kg)	10.72	10.72	9.65	9.65	10.72	10.72	9.65
Bean price standard deviation	2.14	2.14	1.93	1.93	2.14	2.14	1.93
Bean minimum yield value (kg/ha)	70	20	-72	-125	66	20	-172
Bean base cost (L./ha)	4,269	5,777	4,558	6,065	3,800	5,356	5,644
Corn mean yield value (kg/ha)	1,335	1,335	1,335	1,335	1,335	1,335	1,335
Corn price (L./kg)	5.44	5.44	5.44	5.44	5.44	5.44	5.44
Corn price standard deviation	1.09	1.09	1.09	1.09	1.09	1.09	1.09
Consumption (L.)	34,019	34,019	34,019	34,019	34,019	34,019	34,019
Income from other sources (L.)	21,978	21,978	21,978	21,978	21,978	21,978	21,978
Corn minimum yield value (kg/ha)	45	45	45	45	45	45	45
Corn base cost (L./ha)	4,083	4,083	4,083	4,083	4,083	4,083	4,083
Initial wealth (L.)	108,325	108,325	108,325	108,325	108,325	108,325	108,325
Bean and corn area (ha)	1.9	1.9	1.9	1.9	1.9	1.9	1.9
Bean and corn alpha distribution	5.08	5.08	5.08	5.08	5.08	5.08	5.08
Bean and corn beta distribution	4.50	4.50	4.50	4.50	4.50	4.50	4.50
House value (L.)	43,690	43,690	43,690	43,690	43,690	43,690	43,690

*For each technology category and village, two discount rates (i.e., 0.07 and 0.14) and two coefficients of relative risk aversion (i.e., 2 and 4) were applied. For those choices that include insurance, two loading factors (i.e., 1 and 1.4) and two coverage levels (i.e., 0.45 and 0.75) were used. The bank semi-annual interest rate used was of 0.08. NMTVLI= Non-Mech+TV+LoIn; NMTVHI= Non-Mech+TV+HiIn; NMMVLI= Non-Mech+MV+LoIn; NMMVHI= Non-Mech+MV+HiIn; MTVLI=Mech+TV+LoIn; MTVHI=Mech+TV+HiIn; MMVLI=Mech+MV+LoIn; MMVHI=Mech+MV+HiIn

Table 39. Parameters* used in @Risk for the stochastic present value of wealth utility model for La Cienega farmers, Honduras.

Parameter across technology categories	Technology category						
	NMTVLI	**NMTVHI**	**NMMVLI**	**NMMVHI**	**MTVLI**	**MTVHI**	**MMVHI**
Bean mean yield value (kg/ha)	856	1,056	1,056	1,256	919	1,119	1,319
Bean price (L./kg)	12.99	12.99	11.69	11.69	12.99	12.99	11.69
Bean price standard deviation	2.60	2.60	2.34	2.34	2.60	2.60	2.34
Bean minimum yield value (kg/ha)	70	20	-72	-125	66	20	-172
Bean base cost (L./ha)	4,269	5,777	4,558	6,065	3,800	5,356	5,644
Corn mean yield value (kg/ha)	1,252	1,252	1,252	1,252	1,252	1,252	1,252
Corn price (L./kg)	4.91	4.91	4.91	4.91	4.91	4.91	4.91
Corn price standard deviation	0.98	0.98	0.98	0.98	0.98	0.98	0.98
Consumption (L.)	34,019	34,019	34,019	34,019	34,019	34,019	34,019
Income from other sources (L.)	22,978	22,978	22,978	22,978	22,978	22,978	22,978
Corn minimum yield value (kg/ha)	45	45	45	45	45	45	45
Corn base cost (L./ha)	4,083	4,083	4,083	4,083	4,083	4,083	4,083
Initial wealth (L.)	108,325	108,325	108,325	108,325	108,325	108,325	108,325
Bean and corn area (ha)	1.9	1.9	1.9	1.9	1.9	1.9	1.9
Bean and corn alpha distribution	5.08	5.08	5.08	5.08	5.08	5.08	5.08
Bean and corn beta distribution	4.50	4.50	4.50	4.50	4.50	4.50	4.50
House value (L.)	43,690	43,690	43,690	43,690	43,690	43,690	43,690

*For each technology category and village, two discount rates (i.e., 0.07 and 0.14) and two coefficients of relative risk aversion (i.e., 2 and 4) were applied. For those choices that include insurance, two loading factors (i.e., 1 and 1.4) and two coverage levels (i.e., 0.45 and 0.75) were used. The bank semi-annual interest rate used was of 0.08. NMTVLI= Non-Mech+TV+LoIn; NMTVHI= Non-Mech+TV+HiIn; NMMVLI= Non-Mech+MV+LoIn; NMMVHI= Non-Mech+MV+HiIn; MTVLI=Mech+TV+LoIn; MTVHI=Mech+TV+HiIn; MMVLI=Mech+MV+LoIn; MMVHI=Mech+MV+HiIn

Table 40. Parameters* used in @Risk for the stochastic present value of wealth utility model for Villa de San Francisco and Sabaneta de Valle de Angeles farmers, Honduras.

Parameter across technology categories	**Technology category**						
	NMTVLI	**NMTVHI**	**NMMVLI**	**NMMVHI**	**MTVLI**	**MTVHI**	**MMVHI**
Bean mean yield value (kg/ha)	891	1,091	1,091	1,291	955	1,155	1,355
Bean price (L./kg)	11.17	11.17	10.05	10.05	11.17	11.17	10.05
Bean price standard deviation	2.23	2.23	2.01	2.01	2.23	2.23	2.01
Bean minimum yield value (kg/ha)	70	20	-72	-125	66	20	-172
Bean base cost (L./ha)	4,269	5,777	4,558	6,065	3,800	5,356	5,644
Corn mean yield value (kg/ha)	1,245	1,245	1,245	1,245	1,245	1,245	1,245
Corn price (L./kg)	4.54	4.54	4.54	4.54	4.54	4.54	4.54
Corn price standard deviation	0.91	0.91	0.91	0.91	0.91	0.91	0.91
Consumption (L.)	32,633	32,633	32,633	32,633	32,633	32,633	32,633
Income from other sources (L.)	24,539	24,539	24,539	24,539	24,539	24,539	24,539
Corn minimum yield value (kg/ha)	45	45	45	45	45	45	45
Corn base cost (L./ha)	4,083	4,083	4,083	4,083	4,083	4,083	4,083
Initial wealth (L.)	108,325	108,325	108,325	108,325	108,325	108,325	108,325
Bean and corn area (ha)	1.9	1.9	1.9	1.9	1.9	1.9	1.9
Bean and corn alpha distribution	5.08	5.08	5.08	5.08	5.08	5.08	5.08
Bean and corn beta distribution	4.50	4.50	4.50	4.50	4.50	4.50	4.50
House value (L.)	43,690	43,690	43,690	43,690	43,690	43,690	43,690

*For each technology category and village, two discount rates (i.e., 0.07 and 0.14) and two coefficients of relative risk aversion (i.e., 2 and 4) were applied. For those choices that include insurance, two loading factors (i.e., 1 and 1.4) and two coverage levels (i.e., 0.45 and 0.75) were used. The bank semi-annual interest rate used was of 0.08. NMTVLI= Non-Mech+TV+LoIn; NMTVHI= Non-Mech+TV+HiIn; NMMVLI= Non-Mech+MV+LoIn; NMMVHI= Non-Mech+MV+HiIn; MTVLI=Mech+TV+LoIn; MTVHI=Mech+TV+HiIn; MMVLI=Mech+MV+LoIn; MMVHI=Mech+MV+HiIn

4.4. Correlation Matrix

The correlations between prices and yields at different technology levels are presented in Table 41. The correlation matrix shows that bean prices of modern and traditional bean varieties are highly positively correlated (i.e., when the price of grain of a traditional bean variety increases, the price of the grain of the modern bean variety is expected to increase), while the correlation between corn and bean prices is medium positively correlated (i.e., correlations are 0.52 and 0.45). Also, prices and yields are not correlated for beans and corn.

Table 41. Correlation matrix of simulation random variables.

Random Variables	1*	2	3	4	5	6	7	8	9	10	11	12
1	1.00	0.95	0.52	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	0.95	1.00	0.45	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	0.52	0.45	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	0.00	0.00	0.00	1.00	0.92	0.88	0.88	0.92	0.88	0.88	0.83	0.42
5	0.00	0.00	0.00	0.92	1.00	0.88	0.88	0.88	0.92	0.83	0.88	0.42
6	0.00	0.00	0.00	0.88	0.88	1.00	0.92	0.88	0.83	0.92	0.88	0.42
7	0.00	0.00	0.00	0.88	0.88	0.92	1.00	0.83	0.88	0.88	0.92	0.42
8	0.00	0.00	0.00	0.92	0.88	0.88	0.83	1.00	0.92	0.92	0.88	0.42
9	0.00	0.00	0.00	0.88	0.92	0.83	0.88	0.92	1.00	0.88	0.92	0.42
10	0.00	0.00	0.00	0.88	0.83	0.92	0.88	0.92	0.88	1.00	0.92	0.42
11	0.00	0.00	0.00	0.83	0.88	0.88	0.92	0.88	0.92	0.92	1.00	0.42
12	0.00	0.00	0.00	0.42	0.42	0.42	0.42	0.42	0.42	0.42	0.42	1.00

*1=Traditional Bean Price, 2=Modern Bean Price, 3=Corn Output Price, 4=Bean Yield Non-mechanized Traditional Low Input, 5=Bean Yield Non-mechanized Traditional High Input, 6=Bean Yield Non-mechanized Modern Low Input, 7=Bean Yield Non-mechanized Modern High Input, 8=Bean Yield Mechanical Traditional Low Input, 9=Bean Yield Mechanical Traditional High Input, 10=Bean Yield Mechanical Modern Low Input, 11=Bean Yield Mechanical Modern High Input, 12=Corn Yield Traditional

The purpose of the correlation matrix is to provide information on the strength of association and direction of movement between two variables in the simulations, which also serve as constraints in the simulation runs. Thus, if there is a price increase for the traditional variety in the simulation, on average we would expect also a price increase for beans of a modern variety, and not a random huge decrease. This avoids obtaining runs that would not likely happen in a real life situation.

4.5. Analysis of Crop Insurance in a Portfolio Setting

Crop insurance seems an attractive alternative to reduce income risk when it is presented as a sole alternative to a crop's income. However, when crop insurance is used in a portfolio setting, its impact on risk reduction might be reduced to a modest effect. The diminution of the risk reduction effect is due to the portfolio's risk mitigation effect. This portfolio risk mitigation effect depends on the correlations between the assets included in the portfolio. The closer the correlation of two assets is to negative one the greater the risk mitigation effect. However, even with values close to zero, significant risk reduction can be obtained if the mix of assets is done properly. The difference in the level of risk reduction of crop insurance alone and crop insurance in a portfolio setting also depends on the percentage of that crop's contribution to the total portfolio.

The crops involved in this study's model are beans and corn planted in two different growing seasons. The correlation between beans and corn yields is of 0.42. In addition, off-farm income and income from other activities are included in the portfolio. However, these are constants so there is no correlation of this income with other variables. The percentage contribution of bean income to the total yearly income in the portfolio for the base village La Cienega is 86%. Given the medium correlation and high contribution of beans to the total portfolio, insurance is expected to have medium risk mitigation when included in a farmer's portfolio. The results section for La Cienega and the rest of the villages will show if insurance reduces risk.

The next section provides figures for cdfs that show the risk mitigation effects of crop insurance in a regressive manner (i.e., risk is reduced in a decreasing way) as the type of insurance contracts are presented. Revenue insurance contracts on bean activity as sole source of income are presented first and ending with yield insurance contracts on beans in a portfolio.

4.6. Base Village Simulation and Cumulative Probability Distribution Functions

Cumulative probability distribution functions on revenue, gross income, and end of year wealth will be presented in a regressive manner, a sequence that will show diminishing risk reduction effects as the types of crop insurance contracts change for La Cienega; from revenue insurance contracts to yield insurance contracts; from no copay to copay; from revenue streams to gross income streams; and from sole enterprise (i.e., beans) to portfolio (i.e., beans, corn and gross income from other sources).

Revenue insurance contracts are presented first, even though they are not offered in Honduras, because these types of contracts completely eliminate downside risk for a certain threshold. Thus, this type of contract would be what a farmer might have in mind as the perfect contract.

4.6.1. La Cienega farmers distribution results for with and without insurance

Farmer cumulative probability distribution results (i.e., revenue, gross income, and wealth distributions) for La Cienega will be presented to provide risk reduction comparisons for different types of insurance contracts and income measures (i.e., revenue, gross income, wealth). These distributions will be presented in the following sequence: 1) bean revenue cumulative distribution functions-- without insurance and with insurance contracts (i.e., yield and revenue insurance), 2) bean gross income cumulative distribution functions-- without insurance and with insurance contracts (i.e., yield insurance), 3) total production gross income cumulative distribution functions-- without insurance and with insurance contracts (i.e., yield insurance), and 4) end of year wealth cumulative distribution functions -- without insurance and with insurance contracts (i.e., yield insurance). Within these sequence, insurance contracts with and without copay will be compared, as well as high and low indemnity prices will be compared.

When distributions are presented in this way, it is easier to observe the risk reduction effect of the different types of insurance contracts and of the portfolio. All the cumulative distribution functions in this section are for a traditional variety, non-mechanized land preparation system with low fertilizer use. Also, all insurance contracts specified in the next section will be analyzed for actuarially fair premiums and insurance coverage used in many U.S. contracts (i.e., 75%) to show the risk reducing effect that crop insurance could achieve, since Honduran insurance contracts have coverages of around 45%, which is considered a low coverage and would not likely show a risk reduction. Results of certainty equivalents and insolvency parameters will be presented in the next chapter.

4.6.1.1. Revenue distributions

The revenue crop insurance contract provides the highest risk reduction (i.e., downside risk) to revenue streams. This contract indemnizes whenever revenue falls below a certain threshold (e.g., L. 14,786 in Figure 6). Thus, revenue crop insurance contracts protect against shortfalls in both price and yields, whenever the shortfall of either (i.e., price or yield) or both have an impact large enough to make the revenue lower than the threshold. Yield insurance contracts do not provide this drastic cut of downside revenues because price shortfalls are not covered. Revenue insurance with an actuarially fair premium stochastically dominates in the second degree the no insurance case as it is observed (and verified through tests with the data[36]) in Figure 6.

Once a copay policy is introduced in the revenue insurance contract, the risk is not completely eliminated because the farmer covers some of the loss. This is observed in Figure 7. The revenue insurance curve is no longer vertical but instead has a steep slope. Revenue insurance without copay dominates the copay counterpart (i.e., 20% copay) in the second degree.

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[36] All the statements on stochastic dominance have been verified with the data. For verification of second degree stochastic dominance, the data was ordered in ascending order and accumulated for each series. The accumulated series were later subtracted from each other. If the series of differences changes sign, there is no second degree stochastic dominance. If there is no sign change, the series with the highest values dominates in the second degree. Similarly, for first degree stochastic dominance the data was ordered in ascending order and each series was subtracted from the other. If the series of differences changes sign, there is no first degree stochastic dominance. If there is no sign change, the series with the highest values dominates in the first degree.

Figure 6. Bean revenue (L./ha) cdfs for revenue insurance and no insurance; for Non-mechanized+traditional variety+low input use category, no copay, load=1.00, 75% coverage, high indemnity price.

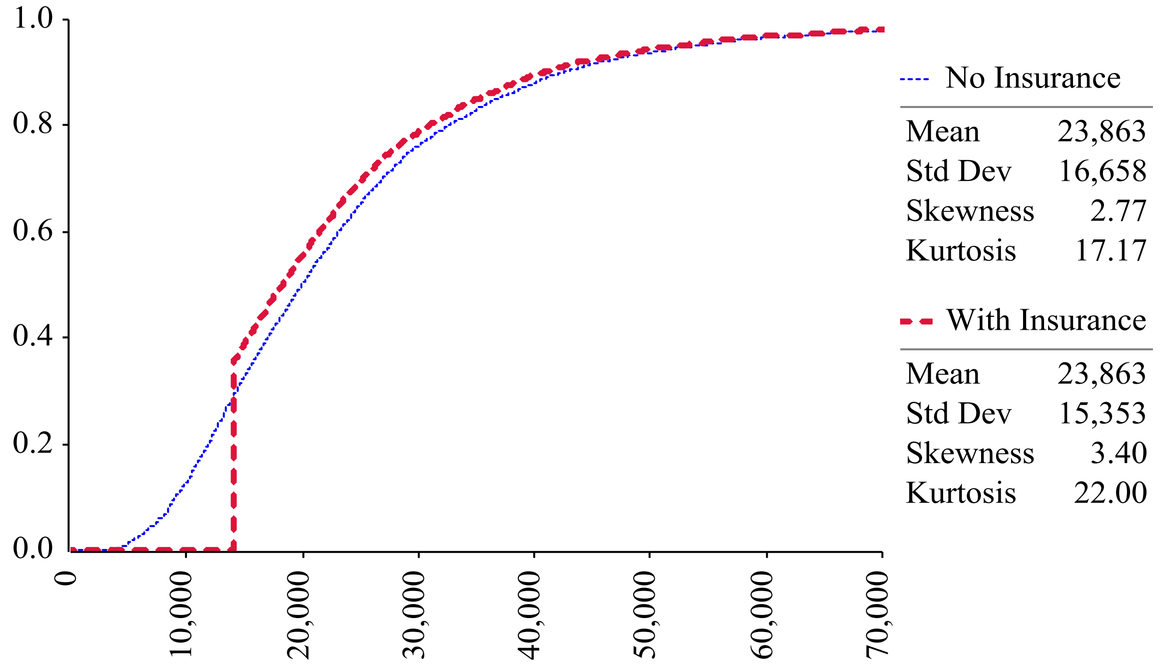
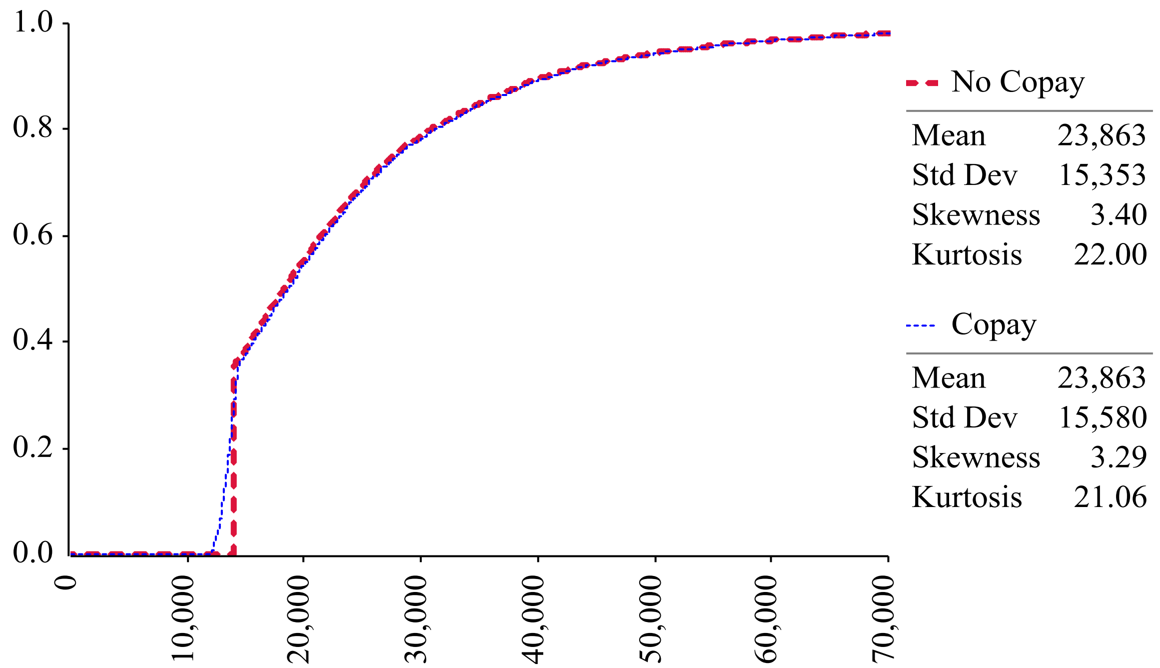


Figure 7. Bean revenue (L./ha) cdfs for revenue insurance with and without copay; for Non-mechanized+traditional variety+low input use category, load=1.00, 75% coverage, high indemnity price.



Yield insurance does not completely eliminate the risk of being below a certain revenue level as revenue insurance does. This can be seen in Figure 8. The reason risk is not completely eliminated is because income is also affected by price of the crop. Thus, there are times when yield insurance has not been triggered and no indemnity has been paid, nevertheless, the price is low enough that income is below the minimum income threshold used for the revenue insurance case. In this case, there is no stochastic dominance in the second degree.

Figure 8. Bean revenue (L./ha) cdfs for revenue insurance and yield insurance; for Non-mechanized+traditional variety+low input use category, no copay, load=1.00, 75% coverage, high indemnity price.

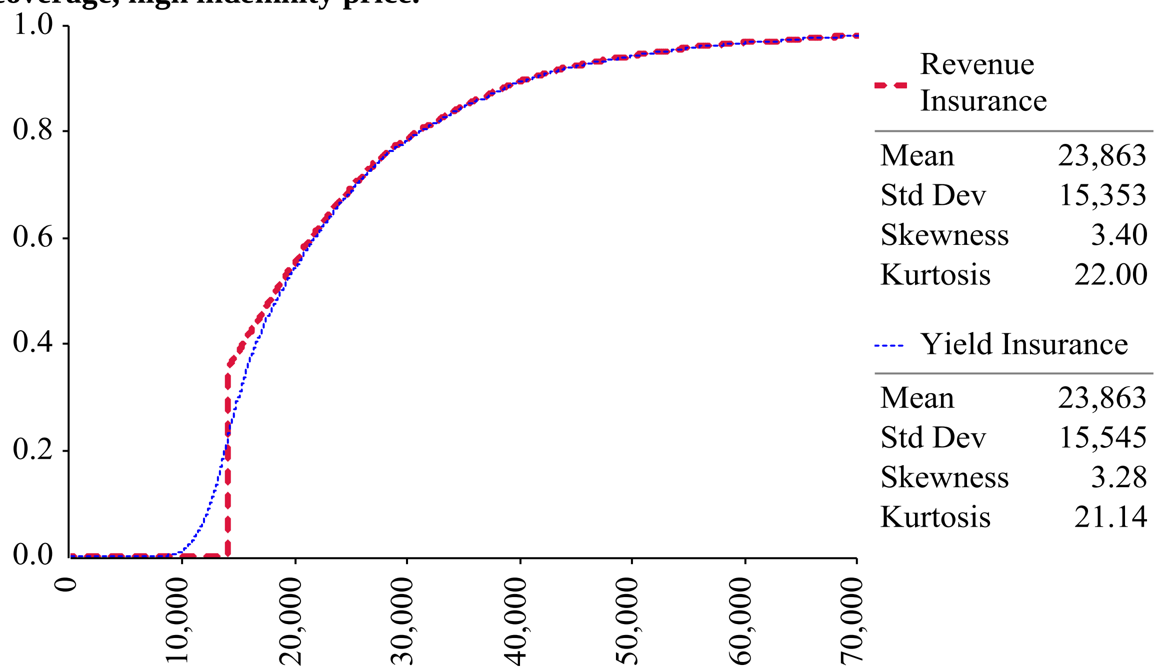
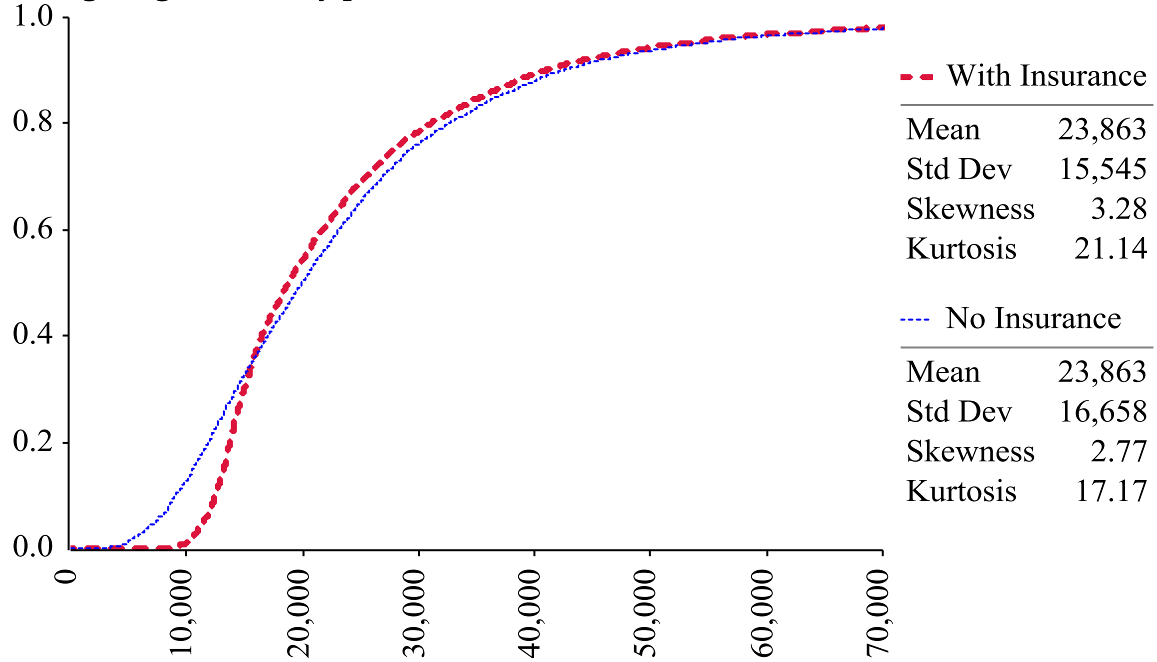


Figure 9 shows bean total revenue distributions with and without yield insurance. As expected, the yield insurance distribution is below the no insurance case in the lower end of the distribution, which means there is a lower probability of observing low values when insurance is used. This is also seen in the minimum values. As we move along the revenue distribution curve, the insurance curves cross due to the premium paid. We can also observe that since it is an actuarially fair premium, the revenue means are the same.   In this case, the insurance case dominates the no insurance case in the second degree.

Figure 9. Bean revenue (L./ha) cdfs for yield insurance and no insurance; for Non-mechanized+traditional variety+low input use category, no copay, load=1.00, 75% coverage, high indemnity price.



Also, when a copay policy is indicated in an insurance contract the farmer bears some of the losses. This lower protection of an insurance contract with copay is observed in the yield insurance contracts by the reduced area between the curves of a yield insurance contract with copay versus no insurance (Figure 10), compared to the curves of a yield insurance contract and no copay versus no insurance; and also between the yield insurance curves of bean revenues with and without copay (Figure 11). In Figure 10, the insurance case dominates the no insurance case in the second degree and in Figure 11, there is no dominance in the second degree.

Figure 10. Bean revenue (L./ha) cdfs for yield insurance and no insurance; for Non-mechanized+traditional variety+low input use category, with copay, load=1.00, 75% coverage, high indemnity price.

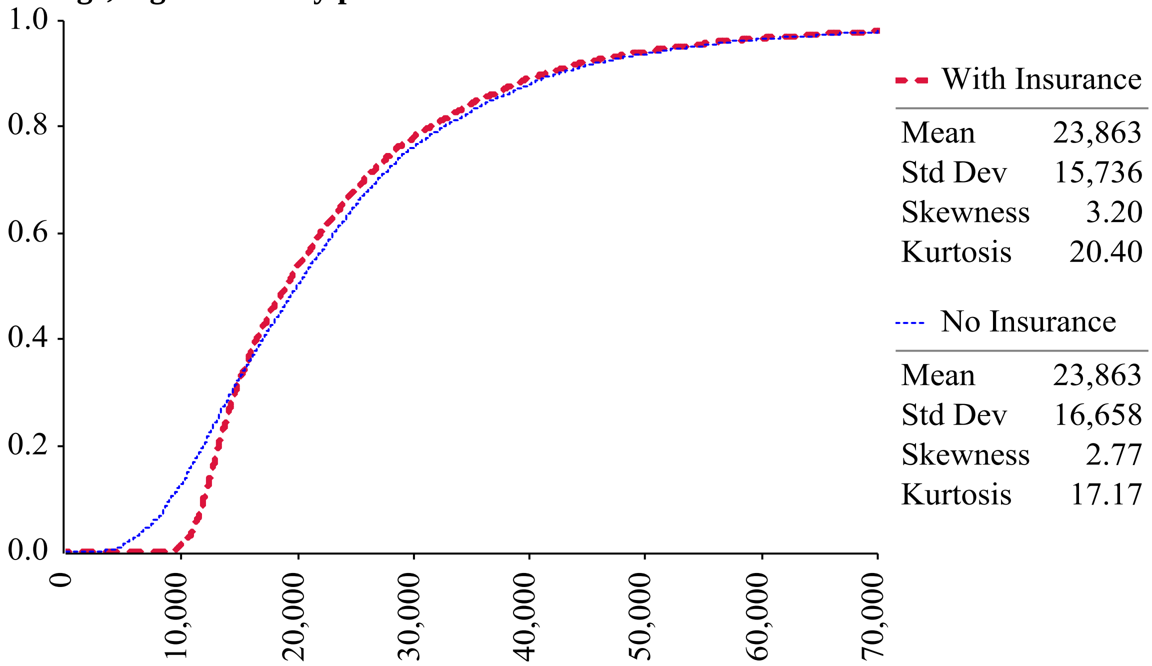
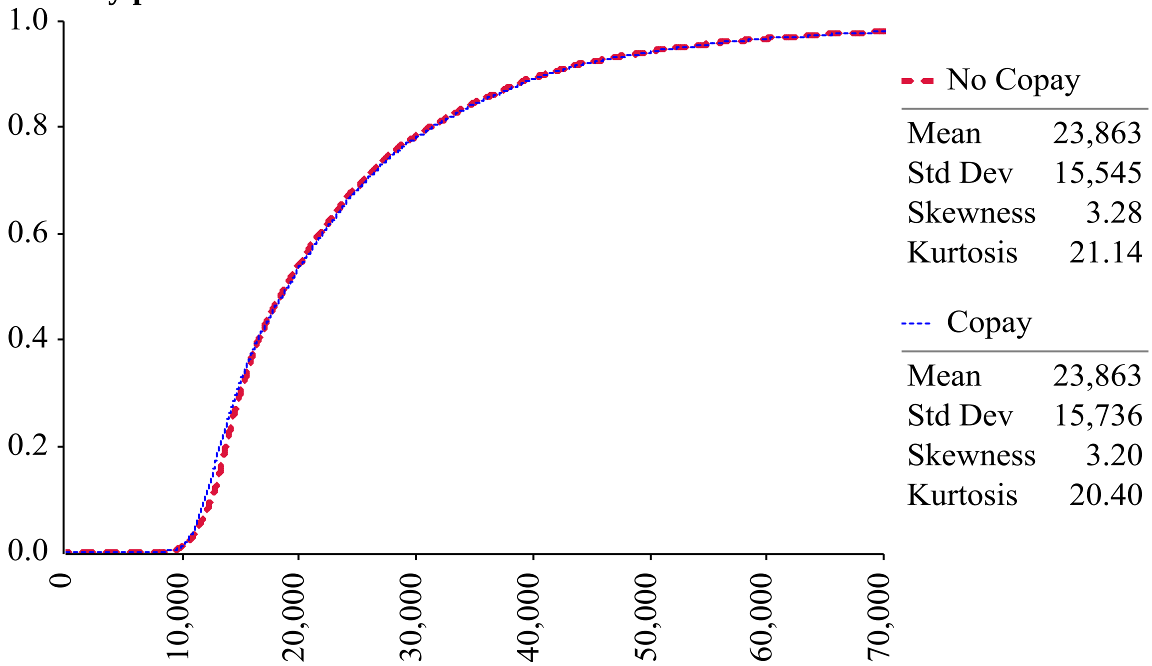
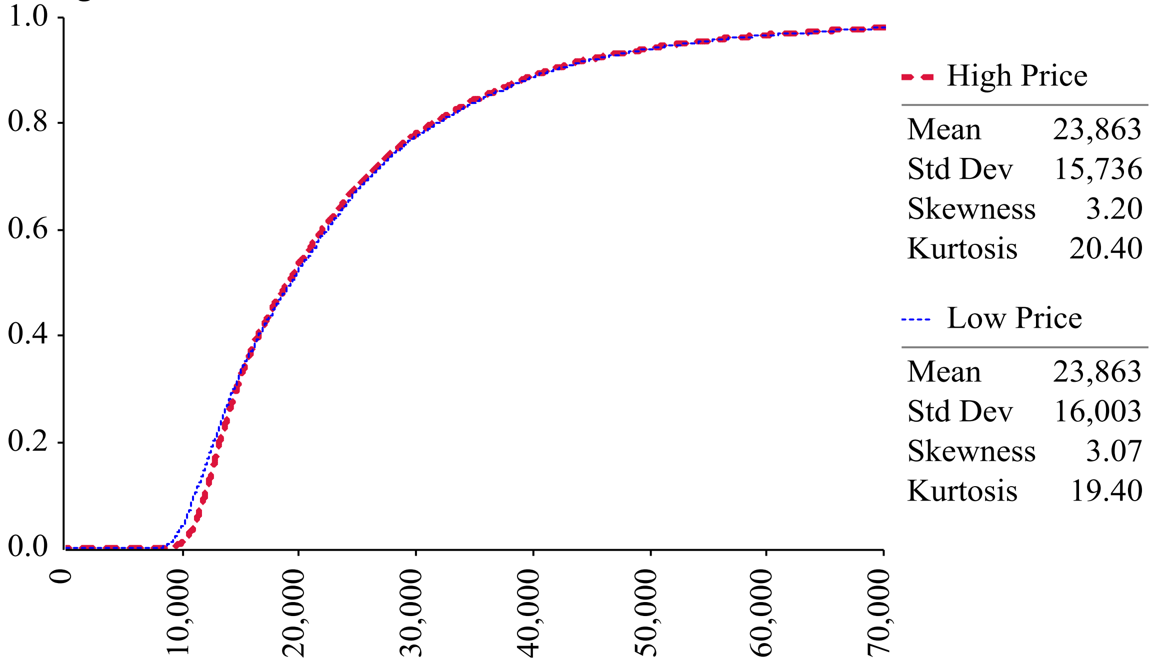


Figure 11. Bean revenue (L./ha) cdfs for yield insurance with and without copay; for Non-mechanized+traditional variety+low input use category, load=1.00, 75% coverage, high indemnity price.



When the indemnity price is lower than the expected price, the risk reduction by the use of insurance is reduced. This is observed in Figure 12, where the high price revenue distribution is below the low price revenue distribution in the lower end of the cdf.

Figure 12. Bean revenue (L./ha) cdfs for yield insurance with high and low indemnity price; for Non-mechanized+traditional variety+low input use category, with copay, load=1.00, 75% coverage.



4.6.1.2. Gross income distributions

Gross income in this study is returns to capital, family labor, land, and management. Gross income distributions in the following sections are first shown for the bean enterprise alone. Later, these gross incomes become part of the marginal wealth (i.e., together with income from other sources) in each year of the 20 year sequence in the SPVWUM, when beans are in the portfolio.

Gross income distributions, compared to revenue distributions, are slightly different in terms of shape but meaningfully different in terms of amounts. It can be observed in Figure 13 how far apart the gross income distribution is from the revenue distribution. The bean gross income and revenue distribution curves are not exactly parallel sigmoid curves in Figure 13. This is because the bean production costs are not fixed, but instead depend on the yield.

Risk reduction by crop insurance on bean gross income is similar to risk reduction on bean revenues in terms of relative shapes of their distribution with and without insurance (i.e., but different in magnitudes). This is observed when comparing gross income distributions of no insurance versus yield insurance, when insurance has a copay and high indemnity price (Figure 14), and low indemnity price (Figure 15). Both Figure 14 and Figure 15 show, as it did for revenue distributions, that yield insurance dominates in the second degree the no insurance case.

Figure 13. Bean revenue (L./ha) and gross income (L./ha) cdfs with no insurance; for Non-mechanized+traditional variety+low input use category.

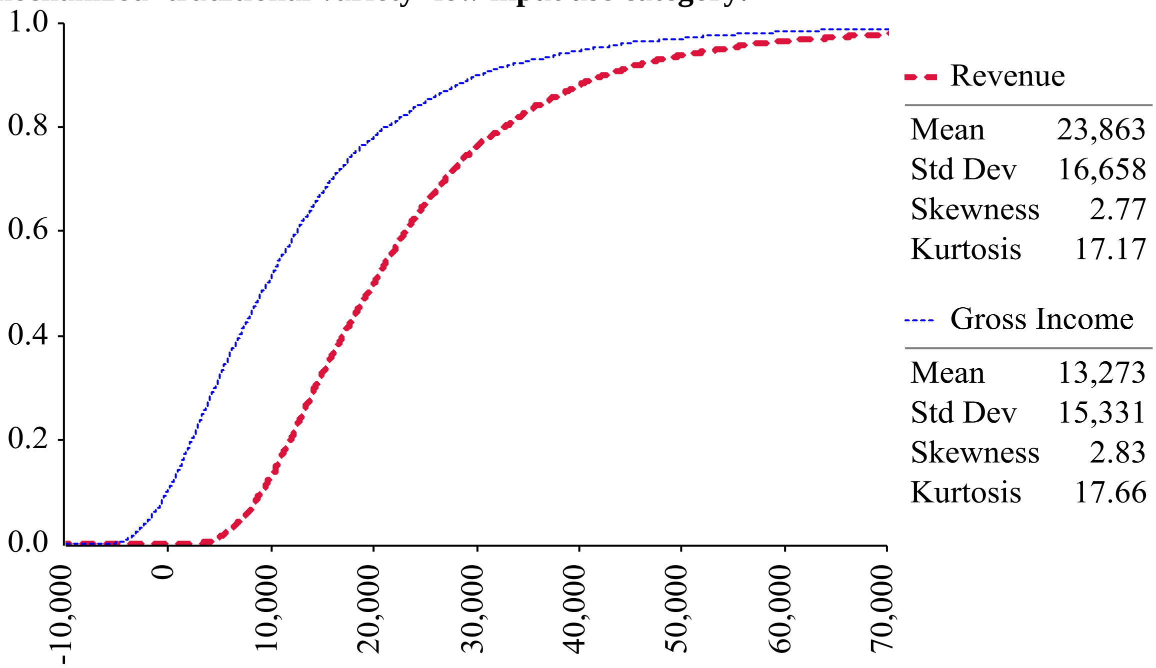


Figure 14. Bean gross income (L./ha) cdfs for yield insurance and no insurance; for Non-mechanized+traditional variety+low input use category, with copay, load=1.00, 75% coverage, high indemnity price.

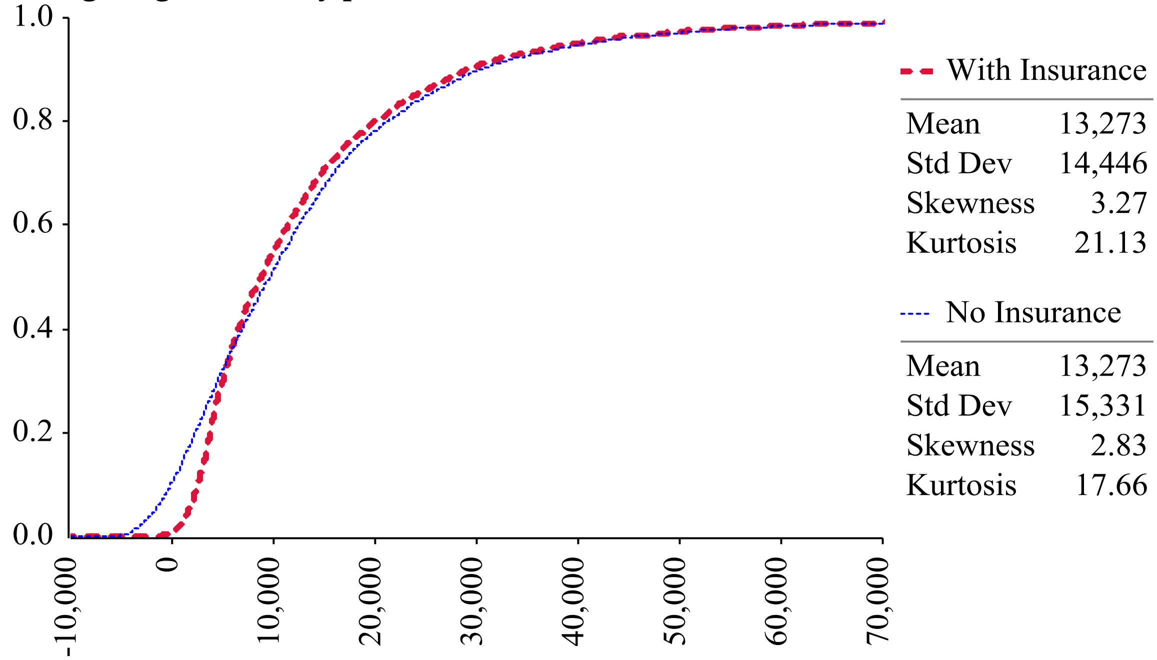
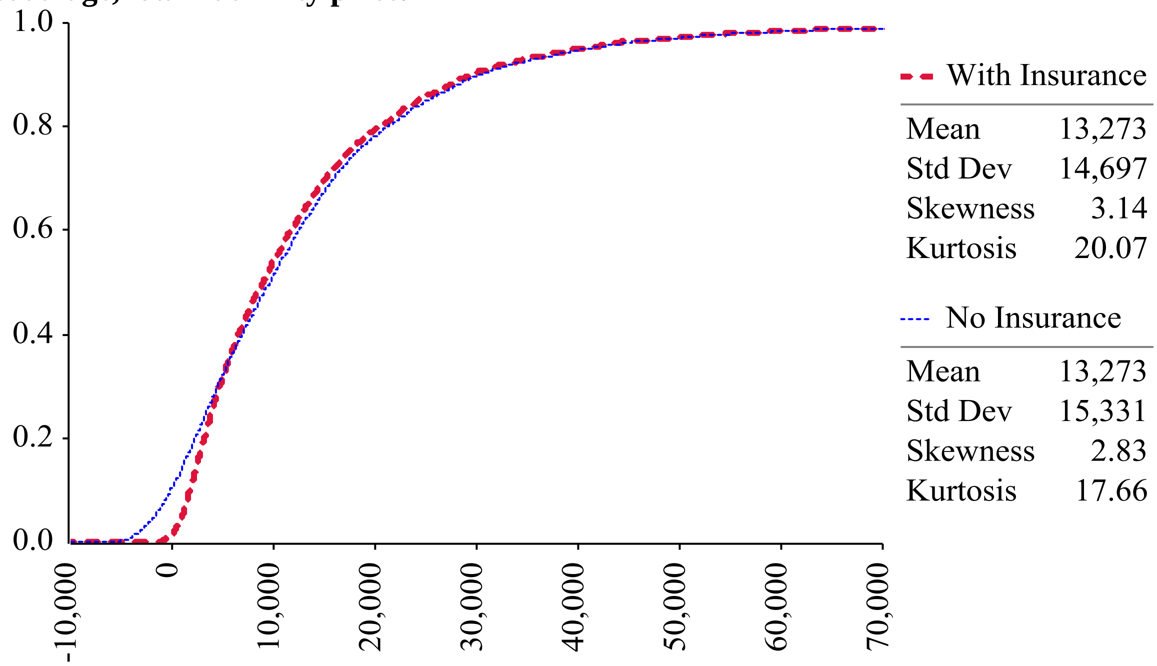


Figure 15. Bean gross income (L./ha) cdfs for yield insurance and no insurance; for Non-mechanized+traditional variety+low input use category, with copay, load=1.00, 75% coverage, low indemnity price.



4.6.1.3. Portfolio distributions

As mentioned before, crop insurance does not reduce risk in the same proportion when there is only one crop, compared to when there are several crops. This is because of the diversification effect or portfolio effect. The risk reduction will depend on the covariance between the two crops and their share of income in the portfolio. To show this, first, the difference in gross revenue magnitudes is shown in Figure 16, when only beans are present compared to when beans and corn are in the portfolio. There is no stochastic dominance in the second degree in Figure 16. Then, Figure 17 shows distributions of corn and beans in a portfolio with and without yield insurance. The area between the curves in Figure 15 in the lower end of these graphs is proportionally higher than the respective area between the curves in Figure 17. This indicates risk reduction by crop insurance is lower in a portfolio, compared to when it is in a sole enterprise. This is one of the reasons why farmers grow several crops. In Figure 17, there is second degree stochastic dominance, although not in first degree.

Figure 16. Gross income cdfs (L./ha) for beans and total production (beans and corn); for Non-mechanized+traditional variety+low input use category and no insurance.

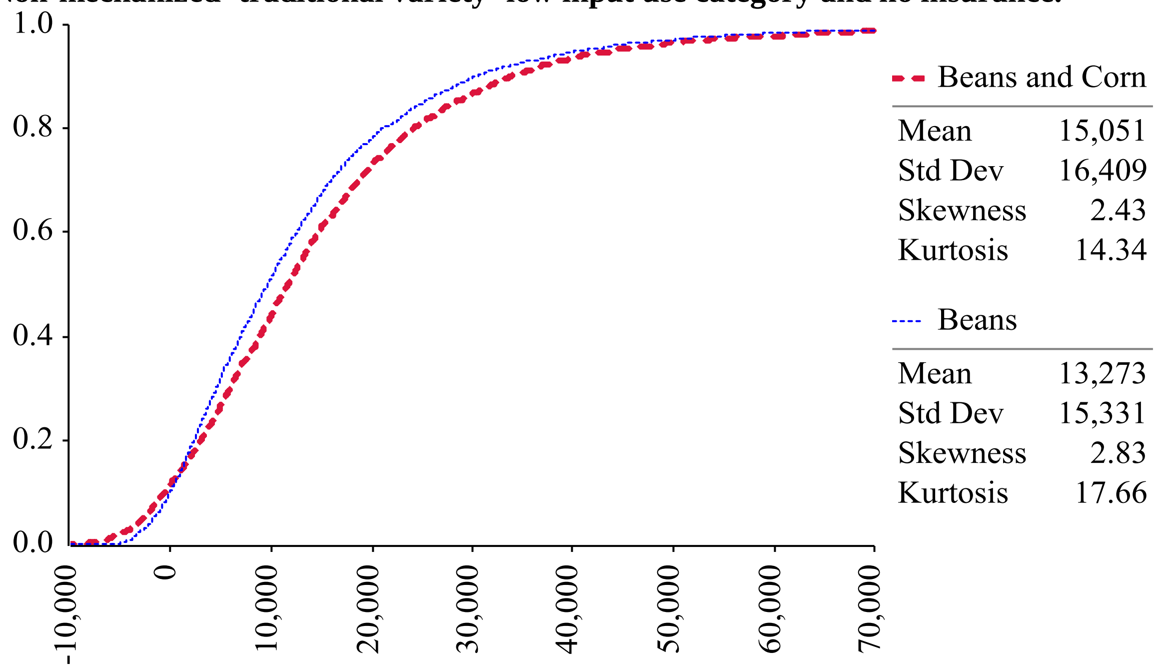
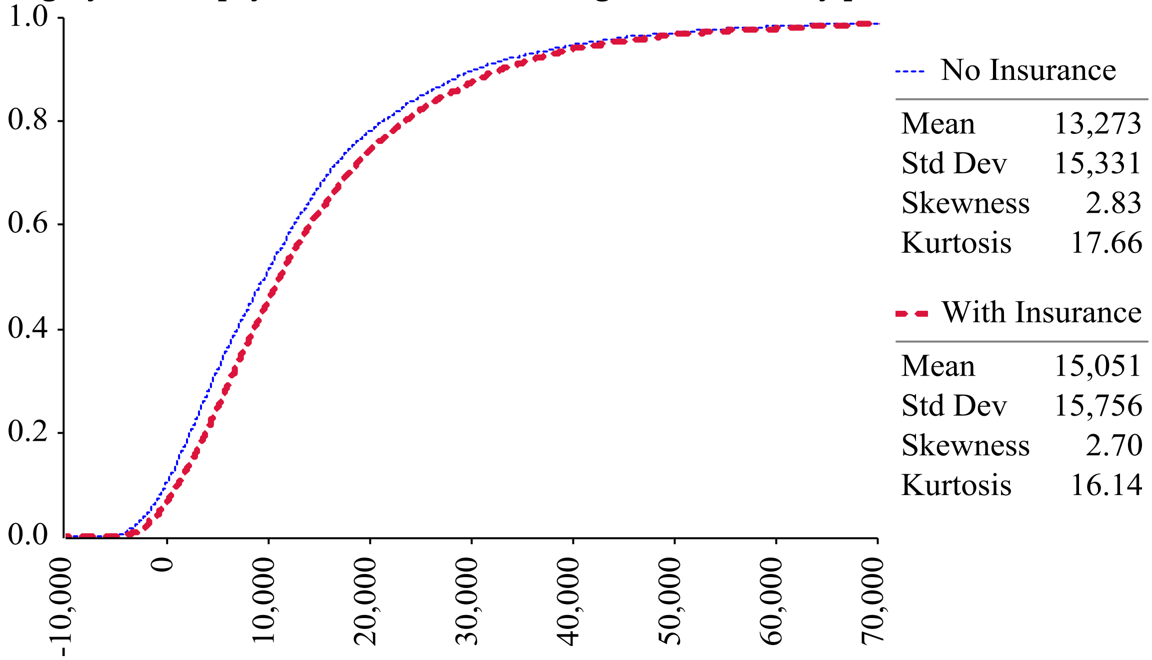


Figure 17. Total production gross income (beans and corn) (L./ha) cdfs for bean yield insurance and no insurance; for Non-mechanized+traditional variety+low input use category, with copay, load=1.00, 75% coverage, low indemnity price.



Finally we move to the whole portfolio setting, which includes bean and corn gross income, and gross income from other sources. The final wealth in year one is the sum of the initial wealth and all the sources of gross incomes (Figure 18). Figure 18 shows the end of year wealth for the first year for both purchasing and not purchasing yield insurance.

After observing the whole portfolio setting for the first year, it is helpful to observe the dynamics through the years of the cdfs of the technology categories. Figure 19 shows the cdfs of end of year wealth at the 20th year for both purchasing and not purchasing yield insurance. Farmers' wealth mean values increase as years increase (compared to Figure 18) due to wealth accumulation--not all outcomes increase the value of wealth, however mean values do. The lower end of the distribution presents an edge (i.e., a step) for both curves. This is due to the farmers that go insolvent after 20 years. Thus, minimum values coincide, given that the threshold to stop producing (insolvency) is the same for both distributions. The maximum value for the insurance case, as expected, is lower than the no insurance case, due to the payment of the premium. In Figure 18 the insurance case stochastically dominates the no insurance case, while in Figure 19 it does not. The reason for the difference in stochastic dominance is the insolvency inclusion in the simulation takes effect after several years impacting more on the insurance case.

Figure 18. End of first year wealth (L.) cdfs for yield insurance and no insurance; for Non-mechanized+traditional variety+low input use category, with copay, load=1.00, 75% coverage, low indemnity price.

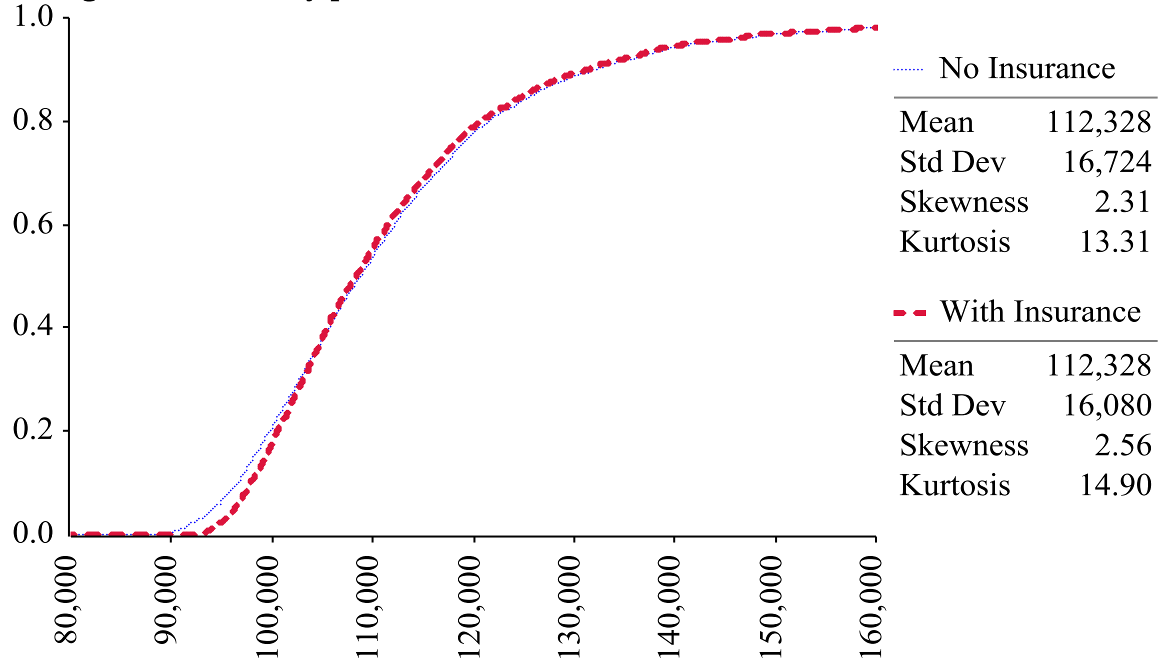
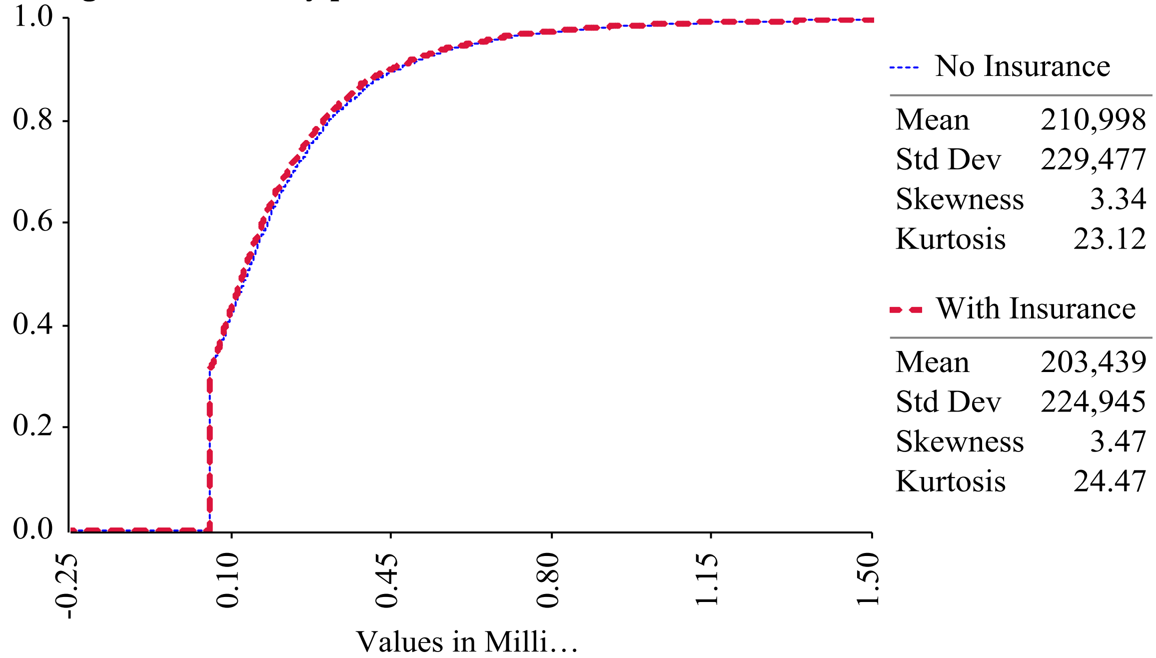


Figure 19. End of twentieth year wealth (L.) cdfs for yield insurance and no insurance; for Non-mechanized+traditional variety+low input use category, with copay, load=1.00, 75% coverage, low indemnity price.



4.6.1.4. Chance of not meeting consumption expenditures

After running simulations with the whole portfolio, farmers in each village growing traditional varieties would have different chances of not meeting their consumption expenditures. Within each village the value would change if insurance was used on the traditional variety. These chances were observed at each village and for the case of insurance and no insurance by looking at the height of the cumulative probability density functions of accumulated wealth in year one at the point of initial wealth minus half of the consumption expenditures. The chances of not meeting consumption expenditures for the case of no insurance and for villages La Cienega, Talanga and Guaimaca, Arauli and Chirinos, Alauca, and Villa de San Francisco and Sabaneta de Valle de Angeles are 10.8%, 11.1%, 1.6%, 25.6%, and 6%, respectively. The chances of not meeting consumption expenditures for the case of insurance and for villages La Cienega, Talanga and Guaimaca, Arauli and Chirinos, Alauca, and Villa de San Francisco and

Sabaneta de Valle de Angeles are 10.4%, 10.6%, 0.8%, 25.6%, and 5.1%, respectively. Almost in all villages farmers reduce the chance of not meeting consumption expenditures when using insurance, except for Alauca. The average chance of not meeting consumption expenditures reduces from 11.02% without insurance to 10.5% with insurance.

4.7. Chapter Summary

The study uses data collected from key informant interviews, survey data and secondary data. The key informants interviewed were personnel from insurance companies, banks, and microcredit institutions. The insurance companies personnel interviewed in the study were from ProAgro, HSBC, Seguros Equidad and Seguros Atlantida. The banks and microcredit personnel interviewed in the study were from BAMER, Ficohsa, HSBC, Banco de Occidente, Banco Atlántida, and ODEF. Interest rates charged by banks ranged from 10% to 18%. The study used a semi-annual interest rate of 8% and a rate of time preference of 7% and 14%, which includes a middle value within the range of interest rate as well as a lower value to observe the effect of the discount rate on farmers.

Crop insurance coverages were approximately 45% in Honduras and with high loading factors that ranged from 3-5. Copays in the contracts offered by insurance companies in Honduras are from 15% to 30% depending on the peril. The study used coverages of 45% and 75% to observe the effect of the coverage on farmers. The study also used actuarially fair premiums as well as a load of 1.4, as it is thought to be a reasonable loading factor for insurance companies to charge.

Enumerator bias was found on the subjective yield probability distributions of corn and beans. Due to this, bean and corn yields were obtained through a mix of elicitation of farmer subjective yield distributions, secondary data, and expert opinion. Time series data at the market level in the capital city of Tegucigalpa revealed that beans have approximately a 19% CV, and corn has a 16% CV, which were adjusted due to differences of CVs from the market level and the farm level, and because of experiences seen at other studies. The adjustment made was for bean farmers to face a coefficient of variation (CV) of 20% for both bean and corn price. Based on farmers elicited yield distributions and experiences seen at other studies, farmers face a perceived yield risk at a range of approximately 32-34% CV for beans depending on the bean technology, and 32% for traditional corn varieties.

Consumption expenditures were obtained from the farmer survey. Income from other sources was adjusted from the value obtained from the survey to a new amount which would be enough to add, together with production gross income, to be 3% above the consumption expenditures. All previous information was used to run the stochastic present value of wealth utility model. In addition, farmers were asked how they coped with disaster. Farmers cope with income shortages by mainly relying in working in another job besides their crop enterprise (50%), selling their assets (24%), and asking for a loan from friends, family or other person (14%). Graphs show how different types of insurance contracts work, specifically showing how stochastic dominance is sometimes achieved by the insurance case compared to no insurance. Finally, graphs also show how likely a farmer to not meet his /her consumption expenditures is.

5. CHAPTER V: Results and Analysis

This chapter presents the results to assess the benefits of a credit-insurance package for bean farmers in Honduras.

5.1. Certainty Equivalent Ratios

The comparison analysis presented in this chapter consists of comparing the metrics certainty equivalents (CE), certainty equivalent ratios (CER), and insolvency percentages (IP), for each of the choices (i.e., combination of technology categories, and use of credit and insurance) and villages. Similar to the probability distribution analysis, certainty equivalents and insolvency percentages are presented for all villages. Then results are presented for each village as well as comparisons of main aspects between villages.

Certainty equivalent ratios are introduced in this section to observe a percentage change in CE for changes in variety package and/or credit-insurance package, for a certain type of farmer. The CERs are ratios of CE for two levels of one factor, where the base level is placed in the denominator. For example, the variety package CER is used to compare if the change in variety package is perceived to be beneficial by the farmer. In this case, the traditional variety package (base) is in the denominator and the modern variety package is in the numerator, for a specific level of coverage, loading factor, CRRAC, and discount rate. However, to compare across different levels of credit-insurance packages, the CERs are directly compared, *ceteris paribus*. For example, farmers perceive a benefit for a certain level compared to another level of coverage, loading factor, CRRAC, or discount rate, when the CER is higher for the former level. These ratios are obtained by dividing specific certainty equivalents from Table 75 to Table 114 in the Appendices.

A specific example of a CER is the ratio of the CE of a moderately risk averse farmer (CRRAC=2) from La Cienega using a non-mechanized land preparation system, using a modern variety with high level of inputs, an actuarially fair insurance with a 75% coverage, a discount rate of 7% and no credit, compared to the same farmer using a traditional variety with low level of inputs, and without the use of insurance nor credit. The previous example is the CER for change in variety package. The ratios are estimated for several types of credit-insurance packages (i.e., combination of load, coverages, with and without credit) and farmer characteristics (i.e., risk aversion, time preference rate (discount rate)). The base level within each village and type of farmer (e.g., CRRAC=2 and discount rate of 7%) is the traditional variety package (traditional variety, low level of input) with no credit and no insurance.

The input level certainty equivalent ratio is estimated by dividing the certainty equivalent for the high input level by the low input level (i.e., base level) within the same type of variety (i.e., traditional or modern variety), land preparation system[37], and village. The ratio is estimated for several farmer characteristics (i.e., risk aversion, discount rate); however, this CER is only estimated for the case of no insurance and no credit.

Pairwise comparisons are made between CERs across the levels of the characteristic of interest for comparing insurance contract characteristics (i.e., coverages, loads), farmer characteristics (i.e., discount rates, risk aversion), and credit need. For example, to compare the effect of risk aversion on the perception if the change in modern variety package is beneficial, the variety package certainty equivalent ratios would be compared across the two levels of risk aversion.

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[37] Type of land preparation is not compared due to problems in the problem setup.

In the following sections, certainty equivalent ratios or comparisons between these ratios are discussed to observe the effects of variety package, fertilizer, type of variety, insurance contract characteristics, farmer characteristics, and use of credit. The end of the chapter discusses the results for the two cases of interest previously described to asses if a credit insurance package could increase the adoption of a modern variety package.

5.2. Effects of Variety Packages, Credit Insurance Packages, and Farmer Characteristics.

The effects of variety packages, credit-insurance packages, and farmer characteristics are discussed in a manner that shows the general trend of a change in the levels of each the packages or characteristics. The discussion on the credit-insurance packages will provide insights into the reasons why some combination of insurance characteristics and farmer characteristics do not follow the general trend of increasing or decreasing CEs within the two cases of interest (i.e., risk averse farmer and not capital constrained, and risk averse farmer and capital constrained). It will provide a discussion on interaction effects between those characteristics.

5.2.1. Modern variety package change

The effect of the change from a traditional variety to a modern variety package is analyzed here only for the no credit and no insurance case. Throughout all villages, results show (Tables 42-46) CERs equal to or higher than one for the change in variety package for moderately risk averse farmers (i.e., CRRAC of 2). This means that there is a trend of increasing CEs for moderately risk averse farmers in all villages when these farmers change from a traditional variety package to a modern variety package, independent of discount rate.

Table 42. CE ratios of modern variety package over traditional variety package for each land preparation system and credit-insurance package in La Cienega.

Land Preparation System	Discount rate (%)	CRRAC	No Credit					With Credit			
			No Insurance	Load							
				1.0		1.4		1.0		1.4	
				Coverage		Coverage		Coverage		Coverage	
				45%	75%	45%	75%	45%	75%	45%	75%
Non-Mechanized	7	2	1.08	1.07	1.08	1.06	1.04	1.03	1.03	1.02	1.00
		4	1.00	1.00	1.03	0.99	1.00	0.98	1.00	0.97	0.97
	14	2	1.06	1.06	1.07	1.05	1.04	1.03	1.03	1.02	1.01
		4	1.00	1.00	1.03	1.00	1.00	0.98	1.01	0.98	0.98

Table 43. CE ratios of modern variety package over traditional variety package for each land preparation system and credit-insurance package in Talanga and Guaimaca.

Land Preparation System	Discount rate (%)	CRRAC	No Credit					With Credit			
			No Insurance	Load							
				1.0		1.4		1.0		1.4	
				Coverage		Coverage		Coverage		Coverage	
				45%	75%	45%	75%	45%	75%	45%	75%
Non-Mechanized	7	2	1.00	1.00	1.01	0.99	0.96	0.96	0.96	0.95	0.92
		4	0.95	0.95	0.98	0.94	0.95	0.93	0.95	0.92	0.92
	14	2	1.01	1.01	1.02	1.00	0.98	0.98	0.98	0.97	0.95
		4	0.95	0.96	1.00	0.95	0.96	0.94	0.97	0.94	0.94

Table 44. CE ratios of modern variety package over traditional variety package for each land preparation system and credit-insurance package in Alauca.

Land Preparation System	Discount rate (%)	CRRAC	No Credit					With Credit			
			No Insurance	Load							
				1.0		1.4		1.0		1.4	
				Coverage		Coverage		Coverage		Coverage	
				45%	75%	45%	75%	45%	75%	45%	75%
Non-Mechanized	7	2	1.03	1.03	1.04	1.02	1.00	0.98	0.99	0.97	0.95
		4	0.96	0.97	1.00	0.96	0.97	0.94	0.97	0.94	0.93
	14	2	1.03	1.03	1.05	1.02	1.01	1.00	1.00	0.99	0.97
		4	0.97	0.98	1.02	0.97	0.98	0.96	0.98	0.95	0.95

Table 45. CE ratios of modern variety package over traditional variety package for each land preparation system and credit-insurance package in Arauli and Chirinos.

Land Preparation System	Discount rate (%)	CRRAC	No Credit					With Credit			
			No Insurance	Load							
				1.0		1.4		1.0		1.4	
				Coverage		Coverage		Coverage		Coverage	
				45%	75%	45%	75%	45%	75%	45%	75%
Non-Mechanized	7	2	1.03	1.02	1.02	1.01	0.98	0.98	0.97	0.97	0.94
		4	0.97	0.97	0.99	0.96	0.96	0.94	0.96	0.94	0.93
	14	2	1.03	1.02	1.03	1.01	1.00	0.99	0.99	0.98	0.96
		4	0.97	0.98	1.00	0.97	0.97	0.96	0.97	0.95	0.94

Table 46. CE ratios of modern variety package over traditional variety package for each land preparation system and credit-insurance package in Villa de San Francisco and Sabaneta de Valle de Angeles.

Land Preparation System	Discount rate (%)	CRRAC	No Credit					With Credit			
			No Insurance	Load							
				1.0		1.4		1.0		1.4	
				Coverage		Coverage		Coverage		Coverage	
				45%	75%	45%	75%	45%	75%	45%	75%
Non-Mechanized	7	2	1.04	1.03	1.04	1.02	1.00	0.99	0.99	0.98	0.96
		4	0.97	0.98	1.01	0.97	0.97	0.96	0.98	0.95	0.95
	14	2	1.03	1.03	1.04	1.02	1.01	1.00	1.00	0.99	0.98
		4	0.98	0.98	1.01	0.98	0.98	0.96	0.98	0.96	0.96

However, the threshold set for a change in variety package to be considered beneficial is a CER of 1.03. All moderately risk averse farmers consider it beneficial except for farmers in Talanga and Guaimaca.

On the other hand, high risk averse farmers (i.e., CRRAC of 4) consistently have CERs less than one[38] throughout all villages. The certainty equivalent ratios (CER) for high risk averse farmers range from 0.95 to 0.99. These two results together show that there is a chance to improve farmers wellbeing by introducing a modern variety package with a credit-insurance package for risk averse farmers.

In general, the increase in CER indicates that there is an incentive to change to the modern variety package when the increase is more than modest (i.e., greater than or equal to 3%). A threshold of a CER of 1.03 for a change in variety package is reasonable because of the transaction costs of changing to the new variety package are not included. However, the change in the variety package bundled with a specific credit-insurance package depends on the type of farmer case (i.e., risk averse and not capital constrained, and risk averse and capital constrained).

Results in general show that without the use of insurance, all high risk averse farmers throughout the villages would not adopt the modern variety package because of the higher risk involved in the modern package. However, most moderately risk averse farmers would adopt the package without the use of insurance.

5.2.2. Use of insurance

The use of insurance improves only a few farmers' wellbeing, especially insurance contracts with high coverage (i.e., 75%) with an actuarially fair premium. For instance, all

[38] Cells in La Cienega show a value of one due to rounding.

farmers that do not need credit for using a modern variety package purchasing an actuarially fair insurance contract with a 75% coverage are at least as well off as with a modern variety package without insurance in all villages, except for one case (i.e., in Arauli and Chirinos), and usually better off. This is observed by looking at all CERs greater than or equal to the CERs with no insurance. The modern variety package with an actuarially fair insurance contract of 45% coverage makes many cases of farmers at least as well off. However, for several cases of moderately risk averse farmers with low discount rate (i.e., 7%) and one case for high discount rate (i.e., 14%), their wellbeing is reduced with that variety and insurance package. This is an unusual result because an actuarial fair contract should always be preferred by a risk averse farmer to not having the contract, irrespective of the time frame (i.e., one year vs. many years). However, insolvency is possible in this simulations and this changes the expected result. When insolvency is possible, indemnity payments are not always balanced with the premium paid since those that go insolvent do not receive the indemnity, and makes the change in variety package not attractive. In general, the higher coverage makes the change in variety possible because indemnity payments are made more often, and these indemnity payments received compensate for those that go insolvent, except for the case in Arauli and Chirinos. However, the higher coverage makes the distribution have a lower variability.

In general, the increase in CER enough to justify a change in variety package with an insurance contract with a subsidized premium happens in several cases in La Cienega, Alauca and Villa de San Francisco and Sabaneta de Valle de Angeles, and only for some cases in other villages.

In other ways, a small change from using a modern variety package to a modern variety package with insurance, subsidized or not, might just be worth it for some farmers throughout all villages since the change from one bundle to the other is sometimes just one percentage point above one. However, the only change is the insurance, which might not carry much transaction costs and one percent above unity might be enough for some farmers.

5.2.2.1. Insurance premiums

CER for a variety package change varies according to the insurance premium level. As expected, a subsidized insurance contract (i.e., an actuarially fair premium) increased the CE for the variety package change more than the moderately priced insurance contract (i.e., insurance contract with load of 1.4) in all villages, independent of use of credit, type of farmer and coverage of the insurance contract. This is expected since the former insurance contract covers the same risk at a lower cost for the farmer. This is observed by higher CERs for the subsidized premium compared to the moderately priced insurance premium.

When insurance is not actuarially fair (i.e., load greater than 1), it would not be unsusual to observe that the risk transfer is not enough to compensate farmers, who do not need credit, for the higher cost of the insurance. This is observed in CERs, of a variety package change with insurance contracts with load of 1.4 and 75% coverage, being mostly lower than CERs of a variety package change without insurance. Furthermore, for farmers in all villages is usually the case that insurance does not compensate the risk reduction for the higher cost, except for three cases (i.e., for a high risk averse farmer in Talanga and Guaimaca with a discount rate of 14%; for a high risk averse farmer in Alauca with both discount rates). The cases where insurance does not compensate farmers are the cases where farmers perceive the insurance contract to be too costly for the combination of the risk the insurance transfers and the risk aversion of the farmer. The exceptions listed above, where insurance still compensate farmers' risk transfer, are due to farmers high risk aversion.

5.2.2.2. Coverages

CERs for a variety package change vary according to the insurance coverage level. Farmers in villages find the change in variety packages appealing, depending on the coverages and the premiums. That is, for the specific case of an actuarially fair premium, a farmer would want to fully insure (i.e., have full coverage (100%)) and would reduce its coverage with a less than actuarially fair premium. For example, the CERs for cases of actuarially fair premiums and coverages of 75% are at least as high as the 45% coverage insurance contract counterparts, and usually higher, except for one case where farmers that need credit in Arauli and Chirinos. However, most of the cases of not actuarially fair insurance contracts have CERS higher in the 45% coverage contract compared to the 75% coverage, except for some high risk averse farmers in several villages (e.g., La Cienega). However, this does not mean that the lower coverage will always be preferred to the high coverage level, but it will depend on the level of the load and of the coverage. The result seen for moderately risk averse is the opposite for high risk averse farmers. The result is reversed due to the need of a higher coverage because of a combination of a modern variety package being riskier than the traditional variety package and the higher risk aversion.

5.2.3. Input level

The input level is analyzed by observing the ratios of CEs of high input use over low input use within the same type of farmer (i.e., same discount rate and CRRAC), same variety, and without insurance and credit. The input level refers specifically to fertilizer use. In the Cienega, the CERs for the change in input use level indicate that the change in fertilizer from a low level to a high level is preferred by moderately risk averse farmers, independent of farmers' discount rate and type of variety (Table 47). This does not happen in the same way for farmers in other villages. For farmers in other villages, the change in input level use is also preferred by most moderately risk averse farmers; however, it is preferred only for the traditional variety. This different result between varieties is due to the mix of a constant increase in yield for both varieties by the additional fertilizer applied and to the higher risk in modern varieties. For moderately risk averse farmers, the CERs range from 0.981 to 1.046. CERs for farmers in La Cienega are at least as high for traditional varieties as for modern varieties. In addition, moderately risk averse farmers have higher CERs than high risk averse farmers due to the risk aversion effect by farmers reacting to a higher risk involved in higher fertilizer use. In other villages, most high risk averse farmers with modern varieties have CERs less than one. This means that farmers would prefer not to increase the quantity of fertilizer used within the modern variety, without the use of insurance. In general, this is because of the thicker lower tails of yield probability distributions due to the higher downside risk of higher input use and modern variety use (i.e., the more risky choice in variety use). The differences in villages are due to bean price differences among villages. This situation shows how insurance is important in some situations.

The trend of higher CERs for higher input levels is practically eliminated in all other villages (Table 47, 48 and 49), except for a few cases. The increase in CE in all other villages due to the input change causes a change in CER of at most 1.018 and many less than 1. The difference in CERs being higher in La Cienega is due to the higher price of beans in La Cienega that makes the marginal revenue higher, compared to the marginal cost of fertilizer. This higher marginal revenue in La Cienega results in a higher gross income (i.e., assuming a linear production function) most of the time, compared to other villages.

Table 47. CE ratios of high input use over low input use for each land preparation system and type of farmer (i.e., risk aversion and discount rate) in La Cienega, and Talanga and Guaimaca.

Land Preparation System	Variety and Input Package	La Cienega				Talanga and Guaimaca			
		Discount Rate				Discount Rate			
		7%		14%		7%		14%	
		CRRAC		CRRAC		CRRAC		CRRAC	
		2.0	4.0	2.0	4.0	2.0	4.0	2.0	4.0
Non-Mechanized	Traditional Variety	1.046	1.003	1.037	1.002	0.999	0.968	1.002	0.974
	Modern Variety	1.017	0.989	1.014	0.989	0.990	0.968	0.993	0.971

Table 48. CE ratios of high input use over low input use for each land preparation system and type of farmer (i.e., risk aversion and discount rate) in Alauca and Arauli and Chirinos.

Land Preparation System	Variety and Input Package	Alauca				Arauli and Chirinos			
		Discount Rate				Discount Rate			
		7%		14%		7%		14%	
		CRRAC		CRRAC		CRRAC		CRRAC	
		2.0	4.0	2.0	4.0	2.0	4.0	2.0	4.0
Non-Mechanized	Traditional Variety	1.007	0.973	1.009	0.980	1.000	0.972	1.002	0.977
	Modern Variety	0.981	0.961	0.989	0.967	0.979	0.961	0.985	0.965

Table 49. CE ratios of high input use over low input use for each type of farmer (i.e., risk aversion and discount rate) in Villa de San Francisco and Sabaneta de Valle de Angeles.

Land Preparation System	Variety and Input Package	Discount Rate			
		7%		14%	
		CRRAC		CRRAC	
		2.0	4.0	2.0	4.0
Non-Mechanized	Traditional Variety	1.018	0.982	1.015	0.985
	Modern Variety	0.991	0.970	0.995	0.973

5.2.4. Type of variety

Type of variety is analyzed by observing the ratios of CEs of modern varieties over traditional varieties within the same type of farmer (i.e., same discount rate and CRRAC), and same use of input level without the use of insurance or credit (i.e., Table 50, 51, and 52). The change to a modern variety is preferred by all moderately risk averse farmers throughout all villages. However, the benefits are only modest within the high input use. For several cases with high risk averse farmers the change is not perceived to be beneficial.

The change in variety is perceived to be most beneficial within the low input use. This is because the increase in yield due to the change in variety is the same for both input levels and the high input use is riskier and also has a higher base value, therefore, a lower relative change. The time preference rate also affects the change in variety. In La Cienega, the 7% discount rate has higher CERs than the 14% discount rate, while in Talanga and Guaimaca is reversed. In other villages, this result is mixed depending on the CRRAC. The reason for this is explained in the time preference section below. The trend for the change in variety continues in the same manner as from the change in input use, where the change is preferred by moderately risk averse farmers than to high risk averse farmers and preferred within the low input use (i.e., the less risky choice in input use). Again, this shows how insurance might benefit some farmers depending on their risk aversion, the riskiness of the change in variety and the insurance contract.

Table 50. CE ratios of modern variety use over traditional variety use for each type of farmer (i.e., risk aversion and discount rate) in La Cienega, and Talanga and Guaimaca.

Land Preparation System	Input Level	La Cienega				Talanga and Guaimaca			
		Discount Rate				Discount Rate			
		7%		14%		7%		14%	
		CRRAC		CRRAC		CRRAC		CRRAC	
		2.0	4.0	2.0	4.0	2.0	4.0	2.0	4.0
Non-Mechanized	Low input use	1.059	1.007	1.048	1.006	1.013	0.977	1.015	0.983
	High input use	1.029	0.993	1.025	0.993	1.004	0.977	1.006	0.980

Table 51. CE ratios of modern variety use over traditional variety use for each type of farmer (i.e., risk aversion and discount rate) in Villa de San Francisco and Sabaneta de Valle de Angeles, and Alauca

Land Preparation System	Input Level	Villa de San Francisco and Sabaneta de Valle de Angeles				Alauca			
		Discount Rate				Discount Rate			
		7%		14%		7%		14%	
		CRRAC		CRRAC		CRRAC		CRRAC	
		2.0	4.0	2.0	4.0	2.0	4.0	2.0	4.0
Non-Mechanized	Low input use	1.049	1.002	1.040	1.003	1.052	1.000	1.043	1.004
	High input use	1.020	0.989	1.019	0.991	1.025	0.987	1.023	0.991

Table 52. CE ratios of modern variety use over traditional variety use for each type of farmer (i.e., risk aversion and discount rate) in Arauli and Chirinos.

Land Preparation System	Input Level	Arauli			
		Discount Rate			
		7%		14%	
		CRRAC		CRRAC	
		2.0	4.0	2.0	4.0
Non-Mechanized	Low input use	1.050	1.005	1.041	1.007
	High input use	1.028	0.994	1.024	0.994

5.2.5. Farmers' risk aversion and rate of time preferences

The risk aversion level and time preference rate affect the CERs for variety package change. CERs for variety package changes, with and without insurance, are higher for medium risk averse farmers than for high risk averse farmers. This is because high risk averse farmers would be willing to pay more than medium risk averse farmers for a certain pay (i.e., lower CE) within the low risk technology (i.e., traditional variety package), and would pay even more for a certain pay (i.e., lower CE) within a high risk technology (i.e., modern variety package). Thus, given that modern varieties have a higher wealth expected value, CERs are lower for high risk averse farmers.

The time preference or discount rate has different effects on CERs depending on the signs (i.e., positive or negative) of the streams of gross income. When most of the outcomes are positive, increases in the rate of time preference, or discount rate, reduces the CERs for a variety package change because the streams of gross income in the future get discounted more. However, if many of the outcomes in the future are negative, the negative impact is reduced by the higher discount rate. These two effects are observed in the higher CERs in La Cienega for low discount rates, compared to high discount rates, but nearly about the same values or lower in CERs in other villages. Most of the positive outcomes in La Cienega are due to La Cienega's higher bean price.

5.2.6. Use of credit and insurance

CERs have shown that the variety package change is warranted in all villages for moderately risk averse farmers; however, the use of credit and insurance is only warrated for a moderately risk averse farmer in La Cienega for the case of a subsidized insurance contract. In other ways, farmers in Honduras are, for the most part, highly urged by banks to obtain crop insurance to access credit. Thus, for farmers who need credit to change the variety package from a traditional variety package to a modern variety package would need to purchase insurance. However, results in these simulations show that many farmers who need credit would not opt for the change in variety package even with insurance. This can be observed in CERs lower than one for the variety package change for a farmer that needs credit and uses insurance. The interest paid on the credit reduces the CERs. Farmers in La Cienega would perceive the change in variety package beneficial when using credit and insurance, while farmers in other villages would not. The price difference among villages is the reason for the discrepancy.

As it is expected, an insurance contract with a load of 1.4 does have lower CERs than the actuarially fair premium, and this effect is more evident for farmers that need credit. However, one of the hypotheses of this study is that a credit-insurance contract would increase farmer adoption of a modern variety package, and the results observed within farmers that need credit and with a reasonably priced insurance contract are not in accordance to this hypothesis. All risk averse farmers are worst off with the modern variety package together with the insurance contract with 75% coverage and load of 1.4, than the better of the traditional variety package with no insurance and modern variety package without insurance. This means that it is better for moderately risk averse farmers who need credit to not access credit and insurance to change variety package because the mix of interests paid and high premium is not worth compared to the risk transferred and transaction cost involved.

Contrary to many cases discussed above, high risk averse farmers in La Cienega who do not need credit with a subsidized insurance would make the change in variety package. The hypothesis is only partially true for the villages involved, type of insurance contract and type of farmer specified above.

5.2.7. Price of beans

The price of beans has an impact on CERs. This impact has been observed in the differences in CERs among villages. Higher gross income make the change in modern variety package less sensitive to changes in cost from variety package change, changes in farmer discount rate, and cost of credit. La Cienega is the village with the highest price and Arauli and Chirinos are the villages with the lowest price. The Cienega is the village with highest CERs, however, Arauli and Chirinos does not have the lowest CERs; Talanga and Guaimaca has the lowest CERs. This is because the relative increase in gross income is higher in Arauli and Chirinos due to a lower base yield of the traditional variety package, while the increase in yield due to the variety package change is the same, and prices are about same for those villages. Thus, the ratios of CERS would be higher for Arauli and Chirinos. La Cienega have higher bean prices than Talanga and Guaimaca, which results in higher gross income. The higher gross income in La Cienega make the change in modern variety package less sensitive to changes in cost from variety package change, changes in farmer discount rate, and cost of credit.

5.3. Percentage Chance of Going Insolvent

This section will compare the percentage chance of going insolvent (PCGI) for each of the choices for all villages. The percentages of chance of going insolvent for all villages are presented from Table 53 to Table 57.

The change in variety package, from a traditional to a modern variety package, increases the risk, PCGI, because of a thicker lower tail of the modern variety package. This is seen in all villages in Tables 53 through Table 57, where the modern variety package shows at least 0.74 percentage points of PCGI above the traditional variety package, and up to 5.54 percentage points.

In general, insurance does reduce the chance of going insolvent, as long as it has a large enough coverage and is not priced to high. PCGI is lower for farmers that use actuarially fair insurance contracts and high coverage, independent of the need for credit in all villages, except in Arauli and Chirinos. Arauli and Chirinos are the villages with the lower bean price, which would explain why even with insurance these would have higher values of PCGI.

As expected, PCGI values in all villages are lower for high coverages compared to low coverages for actuarially fair insurance contracts. However, these values are higher for moderately priced insurance contracts. This result is due to the decapitalization of the farmer through the years because of the payment of the loaded premium.

One unexpected result is that an insurance contract with an actuarially fair premium and a low coverage has a higher percentage chance of going insolvent than with no insurance. This is a counterintuitive result because the actuarially fair insurance contract should protect more farmers from going insolvent than with no insurance. For one year shot, the actuarially fair insurance contract does protect more farmers; however, with a longer year sequence the result changes. This result is because the premium reduces capital from the farmer while only in a few years the farmer gets indemnized. .

Results of PCGI are not always lower for no credit, which initially one would expect because of the interest payments. There are several cases where the corresponding comparisons of credit are having lower PCGI. This is because of a mix of coverage level, bean price and the switch to traditional variety when the farmer goes below the threshold of being credit-worthy. The higher coverage level decreases the PCGI. Also, the lower bean price villages (i.e., Arauli and Chirinos, and Talanga and Guaimaca) have the farmers that need credit with higher PCGI than those that do not need credit, independent of the coverage or load. However, the village with higher bean price (i.e., La Cienega) has PCGI values lower for farmers that do not need credit compared to those who do. Villa de San Francisco and Sabaneta de Valle de Angeles, the villages with a bean price somewhere in the middle, switch depending on the coverage level and the need for credit.

As expected, subsidized insurance reduces PCGI more than a moderately priced insurance contract because of a lower premium.

The PCGI throughout all villages are in a range from 31.00% to 40.04%. These levels are not within a normal range of other studies (Leatham, et.al., 1987).

It should be noted that all farmers who find the change in variety packages appealing, in terms of CERs, have already taken into consideration the higher risk and higher cost of a modern variety package when coupled with insurance, and still find the change valuable. This would apply for the case of subsidized insurance in La Cienega.

Table 53. Percentage chance of going insolvent for each land preparation system and credit-insurance package in La Cienega.

Land Preparation System	Variety and Input Package	No Credit					With Credit			
		No Insurance	Load							
			1.0		1.4		1.0		1.4	
			Coverage		Coverage		Coverage		Coverage	
			45%	75%	45%	75%	45%	75%	45%	75%
Non-Mechanized	Traditional Variety Low Input	32.64	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.
	Modern Variety High Input	33.38	33.90	32.58	34.56	35.56	33.78	32.14	34.52	35.22

Table 54. Percentage chance of going insolvent for each land preparation system and credit-insurance package in Talanga and Guaimaca.

Land Preparation System	Variety and Input Package	No Credit					With Credit			
		No Insurance	Load							
			1.0		1.4		1.0		1.4	
			Coverage		Coverage		Coverage		Coverage	
			45%	75%	45%	75%	45%	75%	45%	75%
Non-Mechanized	Traditional Variety Low Input	27.26	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.
	Modern Variety High Input	32.36	32.88	31.46	33.62	35.56	33.94	31.72	34.64	36.24

Table 55. Percentage chance of going insolvent for each land preparation system and credit-insurance package in Villa de San Francisco y Sabaneta de Valle de Angeles.

Land Preparation System	Variety and Input Package	No Credit					With Credit			
		No Insurance	Load							
			1.0		1.4		1.0		1.4	
			Coverage		Coverage		Coverage		Coverage	
			45%	75%	45%	75%	45%	75%	45%	75%
Non-Mechanized	Traditional Variety Low Input	31.00	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.
	Modern Variety High Input	34.32	34.64	33.48	35.42	37.24	34.70	32.64	35.26	37.04

Table 56. Percentage chance of going insolvent for each land preparation system and credit-insurance package in Alauca.

Land Preparation System	Variety and Input Package	No Credit					With Credit			
		No Insurance	Load							
			1.0		1.4		1.0		1.4	
			Coverage		Coverage		Coverage		Coverage	
			45%	75%	45%	75%	45%	75%	45%	75%
Non-Mechanized	Traditional Variety Low Input	26.28	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.
	Modern Variety High Input	31.82	32.10	29.44	33.22	34.10	33.30	30.92	34.14	35.42

Table 57. Percentage chance of going insolvent for each land preparation system and credit-insurance package in Arauli and Chirinos.

Land Preparation System	Variety and Input Package	No Credit					With Credit			
		No Insurance	Load							
			1.0		1.4		1.0		1.4	
			Coverage		Coverage		Coverage		Coverage	
			45%	75%	45%	75%	45%	75%	45%	75%
Non-Mechanized	Traditional Variety Low Input	30.40	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.
	Modern Variety High Input	35.06	35.82	35.08	36.78	39.50	36.50	35.42	37.64	40.04

5.4. Results for Cases of Interest

The discussion on the use of a credit-insurance package for adopting a modern variety package will be presented for the two cases of interest: 1) for a risk averse and not capital constrained farmer, and 2) risk averse and capital constrained farmer.

5.4.1. Results for a risk averse and not capital constrained farmer

High risk averse farmers that do not need credit would be the only farmers that would benefit from insurance use for adoption of the modern variety package because moderately risk averse farmers already consider the change in variety package beneficial. Farmers that do not need credit in all villages would not purchase insurance to adopt the modern variety package, except for high risk averse farmers in La Cienega. The risk protection by the insurance is only modest or just not enough to compensate for the risk transferred for high risk averse farmers compared to its base practice of using a traditional variety package. CERs for highly risk averse farmers that do not need credit and use insurance are at most one or two percentage points above the CER of the change in variety package alone or less than 1.03[39], except for a high risk averse farmer in La Cienega. The exception applies only to the subsidized insurance premium (i.e., load=1) case. This can be observed with the CERs of Table 42 which are lower, or modestly higher, than the CER of the variety change only; also observe CE of choices 1 and 5 from Table 4, in Tables 75-114 in Appendices.

The difference in incentive to change variety packages for farmers in La Cienega, compared to farmers in other villages, is the higher price of beans in La Cienega.

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[39] The two conditions were established for the change in variety package to be considered beneficial.

PCGI is decreased by higher insurance coverage and increased by changing variety package from a traditional variety package to a modern variety package.

In summary, the results show that for all cases of reasonably priced insurance contract and even for most cases of the subsidized insurance contract, the insurance package would not help increase the adoption of modern varieties for all farmers that do not need credit in all villages, except for La Cienega.

5.4.2. Results for a risk averse and capital constrained farmer

Contrary to a not capital constrained farmer, both the high or moderate risk averse type of farmer could be benefited by the use of insurance because the change in variety package is only achieved through credit. This means that the comparison of the CER is with only the threshold of 1.03 and not with both conditions established before.

Farmers in all villages that need credit to aquire the modern variety package would not acquire the credit-insurance package to adopt the modern variety package, except for moderately risk averse farmers in La Cienega. Moderately risk averse farmers in La Cienega with capital constraints would benefit from the credit-insurance package to change the variety package, as long as the insurance is subsidized with a coverage of 75%. Farmers in all other villages would not be benefited even when subsidized. This result is observed because the interest paid for the credit, above any modest improvements of the use of insurance, is just too high for farmers to make the change. A moderately risk averse farmer in La Cienega who needs credit to purchase the modern variety and inputs would benefit from the credit by being able to purchase the inputs and from the insurance by reducing the downside risk. The credit-insurance package benefit is shown in Table 42, where there are CER values of 1.03 for the subsided insurance contract. Moderately priced insurance would not benefit farmers in any of the villages for farmers that are capital constrained. The change in variety package with capital constrained farmers might be possible if the bean price increases or other parameters change so as to increase the gross income.

As in the previous case of interest, PCGI is decreased by higher insurance coverage and increased by changing variety package from a traditional variety package to a modern variety package.

Again, the difference in incentive to change variety packages for farmers in La Cienega, compared to farmers in other villages, is the higher price of beans in La Cienega.

5.5. Chapter Summary

The metrics certainty equivalent (CE), certainty equivalent ratios (CER) and insolvency percentages were used to compare changes in technology and type of insurance contract for each type of farmer and village. The changes compared were the variety package change as a whole as well as the individual elements of the variety package, levels of different credit-insurance contract characteristics, and differences among villages. The previous is done to answer if the credit-insurance package increases the adoption of a modern variety package for two cases of interest: 1) a risk averse farmer who is not capital constrained, and 2) a risk averse farmer that is capital constrained. The use of a modern variety package alone, without a credit-insurance package, improves the moderate risk averse farmers' wellbeing except for farmers in Talanga and Guaimaca. CER values for moderately risk averse farmers are equal or higher than 1.03, the threshold established to change variety package. The variety package change includes the change in input (i.e., fertilizer) plus the change in variety. Both changes carry more risk for the farmer, thus the perception of increased wellbeing is higher for the moderately risk averse than to the high risk averse.

Farmers in all villages that do not need credit to acquire the modern variety package would not purchase insurance to adopt the modern variety package, except for high risk averse farmers in La Cienega. Farmers in all villages that need credit to acquire the modern variety package would not acquire the credit-insurance package to adopt the modern variety package, except for moderately risk averse farmers in La Cienega. This latter moderately risk averse farmers would benefit from the credit-insurance package if it is actuarially fair with a 75% coverage. The use of insurance, as expected, reduced the percentage chance of going insolvent (PCGI) when the premium is actuarially fair and has high coverage. When it is a moderately priced insurance contract, the PCGI is higher for a high coverage due to decapitalization of the farmer.

6. CHAPTER VI: Conclusions and Recommendations

This section provides the conclusions based on survey results, budgeting, and stochastic simulation runs and recommendations for future research.

Simulations in this study are modeled as a steady state since price and yield have the same mean through time. It also does not facilitate investment so that growth is incorporated. Finally, the study is strongly dependent on the shape of the density functions of price and yield. Moderate changes in this density functions would change the results of whom, if anyone, benefits from the use of the credit-insurance package.

6.1. Conclusions

- The change from a traditional variety to a modern variety is profitable. The partial budget analysis shows that the increase in marginal revenue per hectare due to the change in variety is higher than the marginal costs. Moreover, the change from a traditional variety package (i.e., traditional variety and low levels of inputs) to a modern variety package (i.e., modern variety and high levels of inputs) is even more profitable because the marginal revenue due to the use of fertilizer is greater than the fertilizer marginal cost. Profitability holds throughout all the villages although with varying magnitudes, mainly because of bean price differences among villages.

- Bean farmers face a moderate bean and corn price risk with price distributions with a coefficient of variation (CV) of 20%. Time series data at the market level in the capital city of Tegucigalpa revealed that beans have approximately a 19% CV, and corn has a 16% CV, which were adjusted due to differences of CVs from the market level and the farm level, and because of experiences seen at other studies.

Farmers face a perceived yield risk at a range of approximately 32-34% CV for beans, depending on the bean technology, and 32% for traditional corn varieties. Aggregated data at the regional level in Honduras presented yield distributions with CVs of 14% for beans and 9% for corn. However, aggregated data and farmer level data are very different. Based on farmers elicited yield distributions and experiences seen at other studies the former aforementioned CVs for the farmer level yield risk are appropriate.

Farmer yield distribution elicitation was not successful in this study. Many improper probability distributions were obtained from the elicitation as seen from the shape of the distributions. The elicitation method, and enumerator training and bias were part of the problem of obtaining the improper distributions. The visual impact method without some safety guards is not appropriate for farmers with low schooling and enumerators with few or no experiences in yield distribution elicitation. Enumerators need intensive training on the elicitation procedure. More pre-testing of the elicitation method with more funding would have resulted in better estimation of yield density functions.

In any given year, farmers using a traditional variety package face an 11.0% chance of not being able to meet their normal consumption expenditures without having to resort to a mechanism to cope with shocks. Farmers' cumulative density function at the level of half of their consumption expenditures revealed this chance, given that farmers rely on gross income from risky bean and corn production and assuming a stable income from other sources. Farmers throughout the villages on average reduce modestly that chance to 10.5% in a given year by changing to the modern variety package with a reasonably priced insurance contract for farmers that are not capital constrained.

- Sixty percent of farmers that do not have enough capital to balance their consumption expenditures when perils occur rely mainly on working in another job besides their crop enterprise (50%), selling their assets (24%), and asking for a loan from friends, family or other person (14%).

- Adoption of an improved variety package can occur when the change in package is profitable, even without the use of insurance. However, price and yield risk can deter adoption of the modern package even when it is profitable to do so. Some risk averse farmers would not adopt a riskier variety package because of the effect bad outcomes has on their livelihoods. Insurance is a risk management tool that allows risk averse farmers adopt technologies when faced with the previous situation.

- There is no literature on evaluations of existing insurance policies in Honduras regarding their coverage and loading. Crop insurance companies in Honduras offer catastrophic crop insurance policies (i.e., coverages of 45%) that do not provide high levels of risk transfer, although the contract provides the means to grow another crop in case of a devastating peril striking. However, the policies offered have unusually high insurance premium loads that range from 3 to 5. A new crop insurance policy is proposed with 75% coverage and a load of 1.0 to incentivize certain type of farmers to adopt modern bean varieties and increase their gross income. This would need government intervention since no insurance company would sell contracts with a load of one. However, this would not be unusual since some funds have been allocated already in the National Development Bank in Honduras (BANADESA for its acronym in Spanish) for purchasing insurance, when this institution lends to farmers.

A subsidized credit-insurance package would help increase the adoption of modern varieties for those that do and do not need credit in La Cienega, however not for other villages.

- Without the use of insurance, all high risk averse farmers throughout the villages would not adopt the modern variety package because of the higher risk involved in the modern package. However, most moderately risk averse farmers would adopt the modern package without the use of insurance.

Farmers in all villages that do not need credit to change to a modern variety package would not benefit from the insurance, except for high risk averse farmers in La Cienega. The risk protection by the insurance is not enough to compensate for the risk transfer for high risk averse farmers.

Farmers in all villages that do need credit to change to a modern variety package would not adopt the modern variety package by using the credit-insurance package, except for low risk averse farmers in La Cienega. The risk protection by the insurance is only modest and not enough to compensate for the transaction costs involved in its acquisition for farmers in other villages. The conditions for these farmers to adopt the modern variety package would be with credit and a subsidized insurance contract with high coverage.

The bean price differential among villages is a determinant factor for adopting a modern variety package in a risky setting with or without the use of insurance and/or credit.

Farmers under general conditions would be benefited by a subsidized credit-insurance package (i.e., load of 1.0) that enables them to change from a traditional variety package (i.e., low fertilizer and traditional seed) to a modern variety package (i.e., high fertilizer level and modern seed).

The specific conditions in which insurance would benefit is when farmers are highly risk averse and do not need credit, living in villages with relatively high prices, or, moderately risk averse farmers that need credit in villages with relatively high prices. The high price has an effect on insurance demand or value to the farmer in those villages with high prices because of the forgone expected gross income of the modern variety is high compared to those farmers in villages with low prices.

Insolvency has an impact on the benefits of insurance. The modern variety package was not preferred in some cases of low coverage, even when covered by an actuarially fair insurance. Insolvency makes indemnity payments to not be balanced with the premium paid. In an actuarially fair insurance, the premium is equal to the expected loss, so indemnity payments received by the farmer through the years would be equal to the premiums paid by him/her. However, farmers that go insolvent do not receive the indemnities from the time they go insolvent and onward, while in the previous years the farmer has already paid the premium. This mismatch in the quantity of indemnity payments made by the insurance company to the farmer and premiums paid by the farmer would act as a load greater than one on the premium and make the change in variety package not attractive.

PCGI is reduced by insurance with high coverage and increased by change in variety package. Both, PCGI and CERs determine the demand for the modern variety package. However, some unexpected results arise sometimes due to the mix of factors and their levels.

6.2. Limitations and Recommendations for Future Research

It is advisable to revisit the approach of estimating the yield probability distributions due to the problems encountered; the general approach has been applied across a broad range of studies. To avoid obtaining improper density functions, it is recommended to include one of two practices when using the visual impact method for yield elicitation as well as intensive enumerator training. The specific visual impact method used in this study provided tokens to farmers for them to assign to a fixed number of intervals created from farmers expressed minimum and maximum yields. The mutually exclusive practices added to that method are: 1) anchor one point by asking the most likely yield; after this value is established, the frequency of the most likely relative to the number of counters must be established; then, counters must be placed on the next to most likely yield to the right, and next to most likely yield to the left, and so on, by asking what is the relative frequency of the interval being filled compared to the most likely interval; finally, farmers must be given a chance to rearrange the counters; and 2) after doing several pre-tests, fix the endpoints for all farmers and then let farmers fill out the yield distribution. These processes will increase the understanding of the concept of relative frequency.

Careful preparation of enumerators is needed. Five day training session should be devoted to enumerators on visual impact method, including three days of field pre-testing. Focus groups with farmers would be preferred to use for each of the technology categories, when farmers are of low schooling.

To determine why farmers who do not need credit would not switch from a traditional bean variety package to a modern bean variety, it is essential to obtain their knowledge and perception of modern varieties regarding yields for both modern and traditional varieties. Also, the cost structure of these farmers in the case of switching to a modern variety is helpful to understand their motives of why are they not using modern varieties. To corroborate or adjust the yield probability distributions, it would be helpful to organize focus groups to elicit their yield probability distributions, cost structure for traditional and modern varieties, creating scenarios of disease pressure and drought, and obtaining the frequency of the scenarios. Thus, researchers should quantify the perception of losses due to disease vulnerability together with rainfall vulnerability to create yield distributions for these common cases of crop loss and better understand the choices farmers make.

To encourage more farmers to obtain crop insurance, coverage levels need to increase with a commensurable premium (i.e., a premium that will also increase suitably) for farmers to perceive appropriate risk transfer and also to reduce the farmers that go insolvent. More efforts are needed on the design of contracts to reduce the effect of moral hazard and adverse selection, which affect crop insurance premiums, to reduce the insurance premiums. For example, collection of yield data at the municipality level to develop area yield insurance contracts of on most productive areas of Honduras. Also, making these data accessible to public, as it is done for rainfall data, which enables to develop weather-index based insurance contracts. The latter type of contracts may need placement of rainfall stations in the most productive areas, which has been one of the constraints of establishing weather-index crop insurance. In addition, doing more research on weather-index insurance, for example, the use of satellite data do develop contracts, would help reduce insurance premiums.

APPENDICES

Appendix 1. Determining yield probability distributions

Table 58. Probability Distribution Analysis of Variance for Traditional Varieties, Honduras 2007.

Source	Type III Sum of Squares	Degrees of Freedom	Mean Square	F-value	p-Value
Corrected Model	3.562(a)	319	.011	4.323	.000
Intercept	14.998	1	14.998	5807.187	.000
Village	.000	9	.000	.000	1.000
Interval	.611	4	.153	59.112	.000
Enumerator	.000	11	.000	.000	1.000
Village*Interval	.151	36	.004	1.619	.013
Village*Enumerator	.000	43	.000	.000	1.000
Interval*Enumerator	.510	44	.012	4.487	.000
Village*Interval*Enumerator	.807	172	.005	1.816	.000
Error	2.208	855	.003		
Total	52.770	1175			
Corrected Total	5.770	1174			

(a) R Squared = .617 (Adjusted R Squared = .475)
Source: Pejuan Bean Farmer Survey, 2007.

Table 59. Probability Distribution Analysis of Variance for Modern Varieties, Honduras 2007.

Source	Type III Sum of Squares	Degrees of Freedom	Mean Square	F-value	p-Value
Corrected Model	1.650(a)	244	.007	2.684	.000
Intercept	8.876	1	8.876	3522.206	.000
Village	.000	9	.000	.000	1.000
Interval	.199	4	.050	19.739	.000
Enumerator	.000	10	.000	.000	1.000
Village*Interval	.204	36	.006	2.247	.000
Village*Enumerator	.000	29	.000	.000	1.000
Interval*Enumerator	.327	40	.008	3.247	.000
Village*Interval*Enumerator	.647	116	.006	2.214	.000
Error	.693	275	.003		
Total	23.143	520			
Corrected Total	2.343	519			

(a) R Squared = .704 (Adjusted R Squared = .442)
Source: Pejuan Bean Farmer Survey, 2007.

Table 60. Probability Distribution Analysis of Variance for Traditional Varieties, Honduras 2007.

Source	Type III Sum of Squares	Degrees of Freedom	Mean Square	F-value	p-value
Corrected Model	3.372(a)	416	.008	3.511	.000
Intercept	3.385	1	3.385	1466.234	.000
Labor Cost per ha	.000	1	.000	.000	1.000
Input Cost per ha	.000	1	.000	.000	1.000
Village (Vill)	.000	9	.000	.000	1.000
Interval (Int)	.364	4	.091	39.461	.000
Enumerator (Enum)	.000	11	.000	.000	1.000
Land Preparation System (LPS)	.000	2	.000	.000	1.000
Vill*Int	.145	36	.004	1.739	.006
Vill*Enum	.000	35	.000	.000	1.000
Int*Enum	.367	44	.008	3.615	.000
Vill*Int*Enum	.455	140	.003	1.409	.004
Vill*LPS	.000	6	.000	.000	1.000
Int*LPS	.036	8	.005	1.956	.050
Vill*Int*LPS	.062	24	.003	1.124	.312
Enum*LPS	.000	9	.000	.000	1.000
Vill*Enum*LPS	.000	1	.000	.000	1.000
Int*Enum*LPS	.103	36	.003	1.244	.160
Vill*Int*Enum*LPS	.017	4	.004	1.818	.124
Error	1.150	498	.002		
Total	41.122	915			
Corrected Total	4.522	914			

a R Squared = .746 (Adjusted R Squared = .533)
Source: Pejuan Bean Farmer Survey, 2007.

Table 61. Probability Distribution Analysis of Variance for Modern Varieties, Honduras 2007.

Source	Type III Sum of Squares	Degrees of Freedom	Mean Square	F-value	p-value
Corrected Model	.314(a)	76	.004	.872	.680
Intercept	.018	1	.018	3.897	.061
Labor Cost per ha	.000	1	.000	.000	1.000
Input Cost per ha	.000	1	.000	.000	1.000
Village (Vill)	.000	2	.000	.000	1.000
Interval (Int)	.024	4	.006	1.272	.310
Enumerator (Enum)	.000	7	.000	.000	1.000
Land Preparation System (LPS)	.000	1	.000	.000	1.000
Vill *Int	.031	8	.004	.831	.584
Vill *Enum	.000	0	.	.	.
Int*Enum	.206	28	.007	1.552	.143
Vill*Int*Enum	.000	0	.	.	.
Vill*LPS	.000	0	.	.	.
Int*LPS	.005	4	.001	.254	.904
Vill*Int*LPS	.000	0	.	.	.
Enum*LPS	.000	0	.	.	.
Vill*Enum*LPS	.000	0	.	.	.
Int*Enum*LPS	.000	0	.	.	.
Vill*Int*Enum*LPS	.000	0	.	.	.
Error	.109	23	.005		
Total	4.422	100			
Corrected Total	.422	99			

a R Squared = .742 (Adjusted R Squared = -.109)
Source: Pejuan Bean Farmer Survey, 2007.

Table 62. Probability Distribution Analysis of Variance for Traditional Varieties (enumerator five removed), Honduras 2007.

Source	Type III Sum of Squares	Degrees of Freedom	Mean Square	F-value	p-value
Corrected Model	3.176(a)	366	.009	3.808	.000
Intercept	3.160	1	3.160	1386.515	.000
Labor Cost per ha	.000	1	.000	.000	1.000
Input Cost per ha	.000	1	.000	.000	1.000
Village (Vill)	.000	8	.000	.000	1.000
Interval (Int)	.354	4	.089	38.872	.000
Enumerator (Enum)	.000	10	.000	.000	1.000
Land Preparation System (LPS)	.000	2	.000	.000	1.000
Vill *Int	.167	32	.005	2.288	.000
Vill*Enum	.000	29	.000	.000	1.000
Int*Enum	.328	40	.008	3.596	.000
Vill*Int*Enum	.368	116	.003	1.394	.009
Vill*LPS	.000	6	.000	.000	1.000
Int*LPS	.048	8	.006	2.613	.008
Vill*Int*LPS	.062	24	.003	1.139	.296
Enum*LPS	.000	7	.000	.000	1.000
Vill*Enum*LPS	.000	1	.000	.000	1.000
Int*Enum*LPS	.079	28	.003	1.238	.190
Vill*Int*Enum*LPS	.017	4	.004	1.842	.120
Error	1.010	443	.002		
Total	36.586	810			
Corrected Total	4.186	809			

(a) R Squared = .759 (Adjusted R Squared = .560)
Source: Pejuan Bean Farmer Survey, 2007.

Table 63. Probability Distribution Analysis of Variance for Modern Varieties (enumerator five removed), Honduras 2007.

Source	Type III Sum of Squares	Degrees of Freedom	Mean Square	F-value	p-value
Corrected Model	.254(a)	61	.004	.745	.805
Intercept	.012	1	.012	2.146	.160
Labor Cost per ha	.000	1	.000	.000	1.000
Input Cost per ha	.000	1	.000	.000	1.000
Village (Vill)	.000	1	.000	.000	1.000
Interval (Int)	.013	4	.003	.601	.666
Enumerator (Enum)	.000	5	.000	.000	1.000
Land Preparation System (LPS)	.000	1	.000	.000	1.000
Vill*Int	.010	4	.002	.429	.786
Vill *Enum	.000	0	.	.	.
Int*Enum	.195	20	.010	1.740	.121
Vill*Int*Enum	.000	0	.	.	.
Vill*LPS	.000	0	.	.	.
Int*LPS	.005	4	.001	.214	.927
Vill*Int*LPS	.000	0	.	.	.
Enum*LPS	.000	0	.	.	.
Vill*Enum*LPS	.000	0	.	.	.
Int*Enum*LPS	.000	0	.	.	.
Vill*Int*Enum*LPS	.000	0	.	.	.
Error	.101	18	.006		
Total	3.555	80			
Corrected Total	.355	79			

a R Squared = .716 (Adjusted R Squared = -.245)
Source: Pejuan Bean Farmer Survey, 2007.

Table 64. T-tests for differences between reported mean and different points of the elicited distribution.

Type of variety and Distribution	Midpoint Value		Maximum Reported	Average Reported	N	Standard Error of mean difference	p-value
	4th Interval	5th Interval					
Traditional variety Half distribution	N.A.	1393	N.A.	1375	83	44.7	0.685
Traditional variety Half distribution	N.A.	N.A.	1550	1375	83	46.6	0.001
Modern variety Half distribution	N.A.	1295	N.A.	1453	51	72.5	0.034
Modern variety Half distribution	N.A.	N.A.	1439	1453	51	75.6	0.854
Traditional variety More than Half distribution	1006	N.A.	N.A.	1091	54	43.4	0.058
Traditional variety More than Half distribution	N.A.	1276	N.A.	1091	54	47.5	0.001
Modern variety More than Half distribution	952	N.A.	N.A.	1248	31	64.2	0.001
Modern variety More than Half distribution	N.A.	1211	N.A.	1248	31	66.3	0.579

N.A.= Not Available/Applicable
Source: Pejuan Bean Farmer Survey, 2007.

Table 65. Traditional Variety Probability Distribution by Village and Interval (Half Distribution).

Village	Interval					Total
	1	2	3	4	5	
SAN PEDRO ALAUCA	0.147	0.107	0.160	0.213	0.373	0.200
	0.151	0.061	0.040	0.061	0.205	0.141
	3	3	3	3	3	15
CHIRINOS	0.099	0.142	0.201	0.247	0.312	0.200
	0.031	0.035	0.015	0.033	0.048	0.083
	13	13	13	13	13	65
ARAULI	0.100	0.132	0.204	0.252	0.312	0.200
	0.034	0.033	0.040	0.033	0.056	0.087
	10	10	10	10	10	50
LA CIENEGA	0.103	0.147	0.206	0.240	0.305	0.200
	0.028	0.023	0.024	0.020	0.044	0.076
	19	19	19	19	19	95
VILLA DE SAN FRANCISCO	0.093	0.147	0.213	0.267	0.280	0.200
	0.023	0.046	0.023	0.023	0.040	0.079
	3	3	3	3	3	15
TALANGA	0.103	0.143	0.194	0.234	0.326	0.200
	0.021	0.039	0.028	0.036	0.054	0.086
	7	7	7	7	7	35
GUAIMACA	0.119	0.151	0.211	0.219	0.300	0.200
	0.057	0.033	0.055	0.041	0.107	0.088
	10	10	10	10	10	50
ZABANETAS	0.120	0.160	0.220	0.240	0.260	0.200
	0.033	0.000	0.023	0.000	0.023	0.057
	4	4	4	4	4	20
Total	0.106	0.143	0.203	0.239	0.308	0.200
	0.043	0.032	0.033	0.033	0.069	0.084
	69	69	69	69	69	345
Source: Pejuan Bean Farmer Survey, 2007.						

Table 66. Traditional Variety Probability Distribution by Village and Interval (More than Half Distribution).

Village	Interval					Total
	1	2	3	4	5	
SAN PEDRO ALAUCA	0.147	0.187	0.240	0.213	0.213	0.200
	0.023	0.023	0.000	0.023	0.046	0.040
	3	3	3	3	3	15
CHIRINOS	0.103	0.183	0.229	0.269	0.217	0.200
	0.031	0.045	0.020	0.050	0.056	0.069
	7	7	7	7	7	35
ARAULI	0.140	0.220	0.200	0.260	0.180	0.200
	0.028	0.028	0.000	0.028	0.028	0.046
	2	2	2	2	2	10
LA CIENEGA	0.116	0.200	0.229	0.244	0.211	0.200
	0.022	0.031	0.044	0.042	0.051	0.059
	11	11	11	11	11	55
VILLA DE SAN FRANCISCO	0.133	0.204	0.244	0.253	0.164	0.200
	0.045	0.042	0.024	0.028	0.068	0.063
	9	9	9	9	9	45
TALANGA	0.093	0.227	0.253	0.240	0.187	0.200
	0.046	0.023	0.023	0.000	0.046	0.066
	3	3	3	3	3	15
GUAIMACA	0.131	0.234	0.240	0.206	0.189	0.200
	0.038	0.071	0.052	0.054	0.103	0.075
	7	7	7	7	7	35
ZABANETAS	0.12	0.2	0.16	0.24	0.28	0.2
	0	0	0	0	0	0.063246
	1	1	1	1	1	5
Total	0.122	0.206	0.233	0.242	0.197	0.200
	0.035	0.044	0.036	0.043	0.065	0.062
	43	43	43	43	43	215
Source: Pejuan Bean Farmer Survey, 2007.						

Appendix 2. Completing the distributions due to problems encountered

Several ways were tried to obtain a complete shape of the yield distribution. The elicited distributions classified as *half distributions* were completed using assuming a normal, right skewed, and left skewed distributions to be able to decide which distribution was sensible to assume, once the distributions were completed. The *more than half distributions* were completed using a triangular distribution.

To complete each type of the *half distributions* (i.e., normal, left skewed, and right skewed distributions), *half distributions* were first pooled across farmers within the same village, technology category, and distribution interval from the elicited yield distribution. With the resulting pooled distributions, interval midpoints were calculated for the second half of the distribution.

To complete the *half distribution* and make it a normal distribution, the interval midpoints followed a mirror image in length of the first half of the distribution. In the same way, probabilities for each interval in the second part of the distribution reflected probabilities (i.e., relative frequency of counters from the elicitation process) in the first part of the distribution resulting in a bell-shaped distribution. For left skewed distribution, the midpoints were calculated in the following way:

Midpoint Interval i = Reported Maximum + (Reported Maximum – Interval Midpoint j) 0.8

i = 6,7,8,9,10 & j = 5,4,3,2,1.

The factor of 0.8 results in a conservative left skewness. The counters for the second part of the distribution were calculated in the following way:

Counters Interval 6 = 1.1* Counters Interval 5

Counters Interval 7 = 1.2* Counters Interval 5

Counters Interval 8 = 1.2* Counters Interval 5

Counters Interval 9 = 0.8* Counters Interval 5

Counters Interval 10 = 0.5* Counters Interval 5

The probabilities are the result of ratio of number of counters in each interval to the total number of counters.

To complete the *half distribution* and assume a right skewed distribution, the midpoints were calculated in the following way:

Midpoint Interval i = Reported Maximum + (Reported Maximum – Interval Midpoint j) 1.2

i = 6,7,8,9,10 & j = 5,4,3,2,1.

The factor of 1.2 results in a conservative right skewness. The counters for the second part of the distribution were calculated in the following way:

Counters Interval 6 = 0.8* Counters Interval 5

Counters Interval 7 = 0.6* Counters Interval 5

Counters Interval 8 = 0.4* Counters Interval 5

Counters Interval 9 = 0.2* Counters Interval 5

Counters Interval 10 = 0.1* Counters Interval 5

Finally, completed *half distributions* were not used because these did not provide a sense of skewness from the beginning.

On the other hand, the *more than half distributions* were tried to be completed by two methods. The first method was eliminated based on the results it provided. The second method provided the empirical distribution parameters.

The first method used to try to complete the *more than half distributions*, assumed a triangular distribution by using a formula that takes into account the midpoint and probability of the highest interval, and assumed 0.5 probability was left to fill. More specifically, the first method used the probability of the highest interval together with the assumed 0.5 probability left to fill the second part of the distribution. With these two pieces of information (i.e., probability of highest interval (i.e., fifth interval), and 0.5 probability) and using Pythagoras Theorem, a new maximum value was estimated. Also, probabilities in between this new maximum and midpoint of the fifth interval were estimated. Finally, when using this method, the maximum values were out of the possible physical range of bean yields and therefore it was not used.

The second method applied to complete the distributions used the midpoints of the interval with the highest probability (X_1), the midpoint of the 5^{th} interval (X_2), and the ratio of the density of the interval with the highest probability to the 5^{th} interval (λ). Pythagoras's theorem was used to obtain the maximum. The maximum yield followed the following equation:

Maximum yield = $\lambda\ (2X_1 - X_2) + X_1$

This equation starts with the assumption that the maximum is the sum of the mode and an adjusted value of the difference between double the mode and the reported maximum. The adjustment is made by multiplying the ratio of the density of the modal interval to the 5^{th} interval density (λ). A higher ratio increases the maximum. Contrarily, the larger the difference between the maximum reported and the mode's midpoint, the lower the maximum expected. This is due to the assumption that a larger section of the distribution was provided by the farmer.

With the new maximum yield estimated, the midpoints of the second part of the distribution were estimated in the following way:

Midpoint Interval i = X_2 + (i – 5)(Maximum Yield – X_2)/5 ; i = {6,7,8,9,10}

Probabilities were calculated by assuming a constant tangent parameter. This tangent ratio is the number of counters in the 5^{th} interval divided by the distance from the estimated maximum yield to the midpoint of the 5^{th} interval. Then, the counters for each interval were calculated in the following way:

Counters in interval i = Tangent ratio* Distance from New Maximum to Midpoint i ; i ={6,7,8,9,10}.

Next, the probabilities for each interval of the completed elicited probability distributions are the result of ratio of number of counters in each interval to the total number of counters. This completion of the elicited distributions was done for all farmers with the *more than half distribution*.

Appendix 3. Village Information

Table 67. Bean and corn yield (kg/ha) response to location, land preparation system, type of variety, and input levels.

Pooled Villages	**Bean**	**Corn**
Alauca	-392**	-793**
	[11.94]	[3.01]
Arauli & Chirinos	-432**	368
	[14.17]	[1.42]
Guaimaca & Talanga	-298**	-573+
	[8.80]	[1.83]
Sabaneta & Villa de San Francisco	-153**	-496+
	[4.99]	[1.87]
Land Preparation System	**65****	**152**
	[2.70]	[0.67]
Type of Variety	5	84
	[0.15]	[0.49]
Input Level	**172****	N.A.
	[8.94]	N.A.
Constant	623**	1,544**
	[27.48]	[8.40]
Observations	196	142
R-squared	0.76	0.18

Absolute value of t statistics in brackets
+ significant at 10%; * significant at 5%; ** significant at 1%
Source: Pejuan Farmer Survey, 2007.

Table 68. Regression of expert opinion on bean and corn yield (kg/ha) responses to rainfall, elevation, and fertilizer.

	Bean	Corn
Rainfall	18.860**	2.741**
	[14.56]	[10.88]
Rain square	-0.019**	N.A.
	[15.33]	N.A.
Elevation	-0.392**	-0.759**
	[7.05]	[6.15]
Fertilizer kg/ha	0.746**	3.447**
	[3.45]	[7.18]
Constant	-3,483.709**	733.026**
	[10.56]	[4.65]
Observations	20	20
R-squared	0.96	0.93
Absolute value of t statistics in brackets + significant at 10%; * significant at 5%; ** significant at 1% Source: Pejuan Farmer Survey, 2007.		

Table 69. Partial budget analysis: change in income for substituting one hectare of a modern bean variety for a traditional bean variety in La Cienega.

<u>Increase</u>		
Increased income:	1056 kg/ha * L. 11.69/kg	L. 12,345
Reduced cost:	0	L. 0
Total increase		L. 12,345
<u>Decrease</u>		
Reduced income:	856 kg/ha * L. 12.99/kg	L. 11,119
Increased cost:		
Seed cost	(((33+11.69+11.69)/3 (L/kg)) – L. 12.99/kg) * 45.45 kg/ha	L. 264
Harvesting and threshing	(1,056-856) kg/ha * L. 1.1/kg	L. 220
Total decrease		L. 11,603
Net change		L 741

Table 70. Partial budget analysis: change in income for substituting one hectare of a modern bean variety for a traditional bean variety in Talanga and Guaimaca.

Increase		
Increased income:	1,246 kg/ha * L. 9.65/kg	L. 12,024
Reduced cost:	0	L. 0
Total increase		L. 12,024
Decrease		
Reduced income:	1,046 kg/ha * L. 10.72/kg	L. 11,213
Increased cost:		
Seed cost	(((33+9.65+9.65)/3 (L/kg)) – L. 10.72/kg) * 45.45 kg/ha	L. 305
Harvesting and threshing	(1,246-1,046) kg/ha * L. 1.1/kg	L. 220
Total decrease		L. 11,738
Net change		L 286

Table 71. Partial budget analysis: change in income for substituting one hectare of a modern bean variety for a traditional bean variety in Arauli and Chirinos.

Increase		
Increased income:	1,051 kg/ha * L. 9.22/kg	L. 9,690
Reduced cost:	0	L. 0
Total increase		L. 9,690
Decrease		
Reduced income:	851 kg/ha * L. 10.24/kg	L. 8,714
Increased cost:		
Seed cost	(((33+9.22+9.22)/3 (L/kg)) – L. 10.24/kg) * 45.45 kg/ha	L. 314
Harvesting and threshing	(1,051-851) kg/ha * L. 1.1/kg	L. 220
Total decrease		L. 9,248
Net change		L 442

Table 72. Partial budget analysis: change in income for substituting one hectare of a modern bean variety for a traditional bean variety in Villa de San Francisco and Sabaneta de Valle de Angeles.

Increase		
Increased income:	1,091 kg/ha * L. 10.05/kg	L. 10,965
Reduced cost:	0	L. 0
Total increase		L. 10,965
Decrease		
Reduced income:	891 kg/ha * L. 11.17/kg	L. 9,952
Increased cost:		
Seed cost	(((33+10.05+10.05)/3 (L/kg)) – L. 11.17/kg) * 45.45 kg/ha	L. 297
Harvesting and threshing	(1,091-891) kg/ha * L. 1.1/kg	L. 220
Total decrease		L. 10,469
Net change		L 495

Table 73. Partial budget analysis: change in income for substituting one hectare of a modern bean variety for a traditional bean variety in Alauca.

Increase		
Increased income:	1,039 kg/ha * L. 9.90/kg	L. 10,286
Reduced cost:	0	L. 0
Total increase		L. 10,286
Decrease		
Reduced income:	839 kg/ha * L. 11.00/kg	L. 9,229
Increased cost:		
Seed cost	(((33+9.90+9.90)/3 (L/kg)) – L. 11.00/kg) * 45.45 kg/ha	L. 300
Harvesting and threshing	(1,039-839) kg/ha * L. 1.1/kg	L. 220
Total decrease		L. 9,749
Net change		L 537

Table 74. Percentage of farmers quoting their main way of coping with perils.

Way of coping with perils	**Percentage**
Look for other sources of income	
Other job	50
Other business	4
Reduce consumption	1
Ask for a loan from a friend or family	6
Ask for a loan in other place	14
Sell assets	24
Other	1
Source: Pejuan Farmer Survey, 2007. N=72. 42 Non responses.	

Table 75. CE* values (L.)* and IP for different technology categories, and credit and crop insurance use for farmers in La Cienega; with a RTP*** of 7%, insurance coverage of 75%, load=1.0, and two CRRAC****.**

Technology Category/credit and insurance	Certainty Equivalent		Percent Insolvent
	CRRAC=2	CRRAC=4	
Non-mechanized+traditional variety+low input use+no credit+no insurance	112,480	93,353	32.26%
Non-mechanized+traditional variety+high input use+no credit+no insurance	117,679	93,597	32.64%
Non-mechanized+modern variety+low input use+no credit+no insurance	119,120	93,956	31.94%
Non-mechanized+modern variety+high input use+no credit+no insurance	121,091	92,947	33.38%
Non-mechanized+modern variety+high input use+no credit+with insurance	121,373	95,928	32.58%
Non-mechanized+modern variety+high input use+with credit+with insurance (switch*****)	116,101	93,416	32.14%
Mechanized+traditional variety+low input use+no credit+no insurance	129,825	104,015	21.58%
Mechanized+traditional variety+high input use+no credit+no insurance	133,667	102,469	24.60%
Mechanized+modern variety+high input use+no credit+no insurance	132,542	97,913	28.80%
Mechanized+modern variety+high input use+no credit+with insurance	135,293	103,718	25.58%
Mechanized+modern variety+high input use+with credit+with insurance (switch)	136,659	105,729	21.40%

* CE=Certainty equivalent; L.=Lempira, Honduran currency.US $1=19.03 in 2007; **IP=insolvency percentage out of 5,000; Insolvent is a producer with an ending period wealth less than or equal to 1.25 times the house value. ; ***RTP=Rate of time preference; ****CRRAC=Constant relative risk aversion coefficient.

*****Switch refers to the farmer switching back from the actual technology category (e.g., non-mechanized land preparation, modern variety, high input) to base technology category (i.e., non-mechanized land preparation, traditional variety, low input). Base category for non-mechanized technologies is non-mechanized traditional low input, and for mechanized technologies is mechanized traditional low input. The switch is done when the farmer is no longer eligible for credit by the bank´s standard (i.e., below 1.75 times the farmer´s house value).

Table 76. CE* values (L.)* and IP for different technology categories, and credit and crop insurance use for farmers in La Cienega; with a RTP*** of 7%, insurance coverage of 75%, load=1.4, and two CRRAC****.**

Technology Category/credit and insurance	Certainty Equivalent		Percent Insolvent
	CRRAC=2	CRRAC=4	
Non-mechanized+traditional variety+low input use+no credit+no insurance	112,480	93,353	32.26%
Non-mechanized+traditional variety+high input use+no credit+no insurance	117,679	93,597	32.64%
Non-mechanized+modern variety+low input use+no credit+no insurance	119,120	93,956	31.94%
Non-mechanized+modern variety+high input use+no credit+no insurance	121,091	92,947	33.38%
Non-mechanized+modern variety+high input use+no credit+with insurance	116,807	92,969	35.56%
Non-mechanized+modern variety+high input use+with credit+with insurance (switch*****)	112,136	90,864	35.22%
Mechanized+traditional variety+low input use+no credit+no insurance	129,825	104,015	21.58%
Mechanized+traditional variety+high input use+no credit+no insurance	133,667	102,469	24.60%
Mechanized+modern variety+high input use+no credit+no insurance	132,542	97,913	28.80%
Mechanized+modern variety+high input use+no credit+with insurance	129,165	99,616	25.58%
Mechanized+modern variety+high input use+with credit+with insurance (switch)	130,615	101,623	21.40%

* CE=Certainty equivalent; L.=Lempira, Honduran currency.US $1=19.03 in 2007; **IP=insolvency percentage out of 5,000; Insolvent is a producer with an ending period wealth less than or equal to 1.25 times the house value. ; ***RTP=Rate of time preference; ****CRRAC=Constant relative risk aversion coefficient.

*****Switch refers to the farmer switching back from the actual technology category (e.g., non-mechanized land preparation, modern variety, high input) to base technology category (i.e., non-mechanized land preparation, traditional variety, low input). Base category for non-mechanized technologies is non-mechanized traditional low input, and for mechanized technologies is mechanized traditional low input. The switch is done when the farmer is no longer eligible for credit by the bank´s standard (i.e., below 1.75 times the farmer´s house value).

Table 77. CE* values (L.)* and IP for different technology categories, and credit and crop insurance use for farmers in La Cienega; with a RTP*** of 7%, insurance coverage of 45%, load=1.0, and two CRRAC****.**

Technology Category/credit and insurance	Certainty Equivalent		Percent Insolvent
	CRRAC=2	CRRAC=4	
Non-mechanized+traditional variety+low input use+no credit+no insurance	112,480	93,353	32.26%
Non-mechanized+traditional variety+high input use+no credit+no insurance	117,679	93,597	32.64%
Non-mechanized+modern variety+low input use+no credit+no insurance	119,120	93,956	31.94%
Non-mechanized+modern variety+high input use+no credit+no insurance	121,091	92,947	33.38%
Non-mechanized+modern variety+high input use+no credit+with insurance	120,507	93,324	33.90%
Non-mechanized+modern variety+high input use+with credit+with insurance (switch*****)	115,819	91,493	33.78%
Mechanized+traditional variety+low input use+no credit+no insurance	129,825	104,015	21.58%
Mechanized+traditional variety+high input use+no credit+no insurance	133,667	102,469	24.60%
Mechanized+modern variety+high input use+no credit+no insurance	132,542	97,913	28.80%
Mechanized+modern variety+high input use+no credit+with insurance	132,377	98,900	28.86%
Mechanized+modern variety+high input use+with credit+with insurance (switch)	133,770	100,844	26.68%

* CE=Certainty equivalent; L.=Lempira, Honduran currency.US $1=19.03 in 2007; **IP=insolvency percentage out of 5,000; Insolvent is a producer with an ending period wealth less than or equal to 1.25 times the house value. ; ***RTP=Rate of time preference; ****CRRAC=Constant relative risk aversion coefficient.

*****Switch refers to the farmer switching back from the actual technology category (e.g., non-mechanized land preparation, modern variety, high input) to base technology category (i.e., non-mechanized land preparation, traditional variety, low input). Base category for non-mechanized technologies is non-mechanized traditional low input, and for mechanized technologies is mechanized traditional low input. The switch is done when the farmer is no longer eligible for credit by the bank´s standard (i.e., below 1.75 times the farmer´s house value).

Table 78. CE* values (L.)* and IP for different technology categories, and credit and crop insurance use for farmers in La Cienega; with a RTP*** of 7%, insurance coverage of 45%, load=1.4, and two CRRAC****.**

Technology Category/credit and insurance	Certainty Equivalent		Percent Insolvent
	CRRAC=2	CRRAC=4	
Non-mechanized+traditional variety+low input use+no credit+no insurance	112,480	93,353	32.26%
Non-mechanized+traditional variety+high input use+no credit+no insurance	117,679	93,597	32.64%
Non-mechanized+modern variety+low input use+no credit+no insurance	119,120	93,956	31.94%
Non-mechanized+modern variety+high input use+no credit+no insurance	121,091	92,947	33.38%
Non-mechanized+modern variety+high input use+no credit+with insurance	119,441	92,710	34.56%
Non-mechanized+modern variety+high input use+with credit+with insurance (switch*****)	114,906	90,980	34.52%
Mechanized+traditional variety+low input use+no credit+no insurance	129,825	104,015	21.58%
Mechanized+traditional variety+high input use+no credit+no insurance	133,667	102,469	24.60%
Mechanized+modern variety+high input use+no credit+no insurance	132,542	97,913	28.80%
Mechanized+modern variety+high input use+no credit+with insurance	136,936	98,064	29.64%
Mechanized+modern variety+high input use+with credit+with insurance (switch)	132,357	100,020	27.46%

* CE=Certainty equivalent; L.=Lempira, Honduran currency.US $1=19.03 in 2007; **IP=insolvency percentage out of 5,000; Insolvent is a producer with an ending period wealth less than or equal to 1.25 times the house value. ; ***RTP=Rate of time preference; ****CRRAC=Constant relative risk aversion coefficient.
*****Switch refers to the farmer switching back from the actual technology category (e.g., non-mechanized land preparation, modern variety, high input) to base technology category (i.e., non-mechanized land preparation, traditional variety, low input). Base category for non-mechanized technologies is non-mechanized traditional low input, and for mechanized technologies is mechanized traditional low input. The switch is done when the farmer is no longer eligible for credit by the bank´s standard (i.e., below 1.75 times the farmer´s house value).

Table 79. CE* values (L.)* and IP for different technology categories, and credit and crop insurance use for farmers in La Cienega; with a RTP*** of 14%, insurance coverage of 75%, load=1.0, and two CRRAC****.**

Technology Category/credit and insurance	**Certainty Equivalent**		**Percent Insolvent**
	CRRAC=2	**CRRAC=4**	
Non-mechanized+traditional variety+low input use+no credit+no insurance	114,132	101,211	32.26%
Non-mechanized+traditional variety+high input use+no credit+no insurance	118,408	101,450	32.64%
Non-mechanized+modern variety+low input use+no credit+no insurance	119,660	101,848	31.94%
Non-mechanized+modern variety+high input use+no credit+no insurance	121,385	100,766	33.38%
Non-mechanized+modern variety+high input use+no credit+with insurance	122,312	104,421	32.58%
Non-mechanized+modern variety+high input use+with credit+with insurance (switch*****)	118,117	101,762	32.14%
Mechanized+traditional variety+low input use+no credit+no insurance	126,997	110,490	21.58%
Mechanized+traditional variety+high input use+no credit+no insurance	130,420	109,672	24.60%
Mechanized+modern variety+high input use+no credit+no insurance	130,578	105,728	28.80%
Mechanized+modern variety+high input use+no credit+with insurance	133,227	111,884	25.58%
Mechanized+modern variety+high input use+with credit+with insurance (switch)	134,119	113,356	21.40%

* CE=Certainty equivalent; L.=Lempira, Honduran currency.US $1=19.03 in 2007; **IP=insolvency percentage out of 5,000; Insolvent is a producer with an ending period wealth less than or equal to 1.25 times the house value. ; ***RTP=Rate of time preference; ****CRRAC=Constant relative risk aversion coefficient.
*****Switch refers to the farmer switching back from the actual technology category (e.g., non-mechanized land preparation, modern variety, high input) to base technology category (i.e., non-mechanized land preparation, traditional variety, low input). Base category for non-mechanized technologies is non-mechanized traditional low input, and for mechanized technologies is mechanized traditional low input. The switch is done when the farmer is no longer eligible for credit by the bank´s standard (i.e., below 1.75 times the farmer´s house value).

Table 80. CE* values (L.)* and IP for different technology categories, and credit and crop insurance use for farmers in La Cienega; with a RTP*** of 14%, insurance coverage of 75%, load=1.4, and two CRRAC****.**

Technology Category/credit and insurance	**Certainty Equivalent**		**Percent Insolvent**
	CRRAC=2	**CRRAC=4**	
Non-mechanized+traditional variety+low input use+no credit+no insurance	114,132	101,211	32.26%
Non-mechanized+traditional variety+high input use+no credit+no insurance	118,408	101,450	32.64%
Non-mechanized+modern variety+low input use+no credit+no insurance	119,660	101,848	31.94%
Non-mechanized+modern variety+high input use+no credit+no insurance	121,385	100,766	33.38%
Non-mechanized+modern variety+high input use+no credit+with insurance	118,690	101,530	35.76%
Non-mechanized+modern variety+high input use+with credit+with insurance (switch*****)	114,919	99,271	35.22%
Mechanized+traditional variety+low input use+no credit+no insurance	126,997	110,790	21.58%
Mechanized+traditional variety+high input use+no credit+no insurance	130,420	109,672	24.60%
Mechanized+modern variety+high input use+no credit+no insurance	130,578	105,728	28.80%
Mechanized+modern variety+high input use+no credit+with insurance	128,630	108,082	29.56%
Mechanized+modern variety+high input use+with credit+with insurance (switch)	129,678	109,699	26.14%

* CE=Certainty equivalent; L.=Lempira, Honduran currency.US $1=19.03 in 2007; **IP=insolvency percentage out of 5,000; Insolvent is a producer with an ending period wealth less than or equal to 1.25 times the house value. ; ***RTP=Rate of time preference; ****CRRAC=Constant relative risk aversion coefficient.
*****Switch refers to the farmer switching back from the actual technology category (e.g., non-mechanized land preparation, modern variety, high input) to base technology category (i.e., non-mechanized land preparation, traditional variety, low input). Base category for non-mechanized technologies is non-mechanized traditional low input, and for mechanized technologies is mechanized traditional low input. The switch is done when the farmer is no longer eligible for credit by the bank´s standard (i.e., below 1.75 times the farmer´s house value).

Table 81. CE* values (L.)* and IP for different technology categories, and credit and crop insurance use for farmers in La Cienega; with a RTP*** of 14%, insurance coverage of 45%, load=1.0, and two CRRAC****.**

Technology Category/credit and insurance	Certainty Equivalent		Percent Insolvent
	CRRAC=2	CRRAC=4	
Non-mechanized+traditional variety+low input use+no credit+no insurance	114,132	101,211	32.26%
Non-mechanized+traditional variety+high input use+no credit+no insurance	118,132	101,450	32.64%
Non-mechanized+modern variety+low input use+no credit+no insurance	119,660	101,848	31.94%
Non-mechanized+modern variety+high input use+no credit+no insurance	121,385	100,766	33.38%
Non-mechanized+modern variety+high input use+no credit+with insurance	121,174	101,443	33.90%
Non-mechanized+modern variety+high input use+with credit+with insurance (switch*****)	117,593	99,643	33.78%
Mechanized+traditional variety+low input use+no credit+no insurance	126,997	110,790	21.58%
Mechanized+traditional variety+high input use+no credit+no insurance	130,420	109,672	24.60%
Mechanized+modern variety+high input use+no credit+no insurance	130,578	105,728	28.80%
Mechanized+modern variety+high input use+no credit+with insurance	130,738	107,059	28.86%
Mechanized+modern variety+high input use+with credit+with insurance (switch)	131,945	108,923	26.68%

* CE=Certainty equivalent; L.=Lempira, Honduran currency.US $1=19.03 in 2007; **IP=insolvency percentage out of 5,000; Insolvent is a producer with an ending period wealth less than or equal to 1.25 times the house value. ; ***RTP=Rate of time preference; ****CRRAC=Constant relative risk aversion coefficient.

*****Switch refers to the farmer switching back from the actual technology category (e.g., non-mechanized land preparation, modern variety, high input) to base technology category (i.e., non-mechanized land preparation, traditional variety, low input). Base category for non-mechanized technologies is non-mechanized traditional low input, and for mechanized technologies is mechanized traditional low input. The switch is done when the farmer is no longer eligible for credit by the bank´s standard (i.e., below 1.75 times the farmer´s house value).

Table 82. CE* values (L.)* and IP for different technology categories, and credit and crop insurance use for farmers in La Cienega; with a RTP*** of 14%, insurance coverage of 45%, load=1.4, and two CRRAC****.**

Technology Category/credit and insurance	Certainty Equivalent		Percent Insolvent
	CRRAC=2	CRRAC=4	
Non-mechanized+traditional variety+low input use+no credit+no insurance	114,132	101,211	32.26%
Non-mechanized+traditional variety+high input use+no credit+no insurance	118,408	101,450	32.64%
Non-mechanized+modern variety+low input use+no credit+no insurance	119,660	101,848	31.94%
Non-mechanized+modern variety+high input use+no credit+no insurance	121,385	100,766	33.38%
Non-mechanized+modern variety+high input use+no credit+with insurance	120,316	100,820	34.56%
Non-mechanized+modern variety+high input use+with credit+with insurance (switch*****)	116,839	99,109	34.52%
Mechanized+traditional variety+low input use+no credit+no insurance	126,997	110,790	21.58%
Mechanized+traditional variety+high input use+no credit+no insurance	130,420	109,672	24.60%
Mechanized+modern variety+high input use+no credit+no insurance	130,578	105,728	28.80%
Mechanized+modern variety+high input use+no credit+with insurance	129,621	106,233	29.64%
Mechanized+modern variety+high input use+with credit+with insurance (switch)	130,870	108,134	27.46%

* CE=Certainty equivalent; L.=Lempira, Honduran currency.US $1=19.03 in 2007; **IP=insolvency percentage out of 5,000; Insolvent is a producer with an ending period wealth less than or equal to 1.25 times the house value. ; ***RTP=Rate of time preference; ****CRRAC=Constant relative risk aversion coefficient.
*****Switch refers to the farmer switching back from the actual technology category (e.g., non-mechanized land preparation, modern variety, high input) to base technology category (i.e., non-mechanized land preparation, traditional variety, low input). Base category for non-mechanized technologies is non-mechanized traditional low input, and for mechanized technologies is mechanized traditional low input. The switch is done when the farmer is no longer eligible for credit by the bank´s standard (i.e., below 1.75 times the farmer´s house value).

Table 83. CE* values (L.)* and IP for different technology categories, and credit and crop insurance use for farmers in Talanga and Guaimaca; with a RTP*** of 7%, insurance coverage of 75%, load=1.0, and two CRRAC****.**

Technology Category/credit and insurance	**Certainty Equivalent**		**Percent Insolvent**
	CRRAC=2	**CRRAC=4**	
Non-mechanized+traditional variety+low input use+no credit+no insurance	120,486	98,689	27.26%
Non-mechanized+traditional variety+high input use+no credit+no insurance	120,342	95,503	30.42%
Non-mechanized+modern variety+low input use+no credit+no insurance	122,082	96,392	29.62%
Non-mechanized+modern variety+high input use+no credit+no insurance	120,813	93,341	32.36%
Non-mechanized+modern variety+high input use+no credit+with insurance	121,203	97,083	31.46%
Non-mechanized+modern variety+high input use+with credit+with insurance (switch*****)	115,656	94,174	31.72%
Mechanized+traditional variety+low input use+no credit+no insurance	137,493	109,122	18.44%
Mechanized+traditional variety+high input use+no credit+no insurance	134,735	103,513	23.22%
Mechanized+modern variety+high input use+no credit+no insurance	130,898	98,133	28.12%
Mechanized+modern variety+high input use+no credit+with insurance	134,795	105,825	22.78%
Mechanized+modern variety+high input use+with credit+with insurance (switch)	136,130	107,827	19.36%

* CE=Certainty equivalent; L.=Lempira, Honduran currency.US $1=19.03 in 2007; **IP=insolvency percentage out of 5,000; Insolvent is a producer with an ending period wealth less than or equal to 1.25 times the house value. ; ***RTP=Rate of time preference; ****CRRAC=Constant relative risk aversion coefficient.

*****Switch refers to the farmer switching back from the actual technology category (e.g., non-mechanized land preparation, modern variety, high input) to base technology category (i.e., non-mechanized land preparation, traditional variety, low input). Base category for non-mechanized technologies is non-mechanized traditional low input, and for mechanized technologies is mechanized traditional low input. The switch is done when the farmer is no longer eligible for credit by the bank´s standard (i.e., below 1.75 times the farmer´s house value).

Table 84. CE* values (L.)* and IP for different technology categories, and credit and crop insurance use for farmers in Talanga and Guaimaca; with a RTP*** of 7%, insurance coverage of 75%, load=1.4, and two CRRAC****.**

Technology Category/credit and insurance	**Certainty Equivalent**		**Percent Insolvent**
	CRRAC=2	**CRRAC=4**	
Non-mechanized+traditional variety+low input use+no credit+no insurance	120,486	98,689	27.26%
Non-mechanized+traditional variety+high input use+no credit+no insurance	120,342	95,503	30.42%
Non-mechanized+modern variety+low input use+no credit+no insurance	122,082	96,392	29.62%
Non-mechanized+modern variety+high input use+no credit+no insurance	120,813	93,341	32.36%
Non-mechanized+modern variety+high input use+no credit+with insurance	115,635	93,301	35.56%
Non-mechanized+modern variety+high input use+with credit+with insurance (switch*****)	110,821	90,920	36.24%
Mechanized+traditional variety+low input use+no credit+no insurance	137,493	109,122	18.44%
Mechanized+traditional variety+high input use+no credit+no insurance	134,735	103,513	23.22%
Mechanized+modern variety+high input use+no credit+no insurance	130,898	98,133	28.12%
Mechanized+modern variety+high input use+no credit+with insurance	127,392	100,479	27.90%
Mechanized+modern variety+high input use+with credit+with insurance (switch)	128,845	102,487	24.64%

* CE=Certainty equivalent; L.=Lempira, Honduran currency.US $1=19.03 in 2007; **IP=insolvency percentage out of 5,000; Insolvent is a producer with an ending period wealth less than or equal to 1.25 times the house value. ; ***RTP=Rate of time preference; ****CRRAC=Constant relative risk aversion coefficient.
*****Switch refers to the farmer switching back from the actual technology category (e.g., non-mechanized land preparation, modern variety, high input) to base technology category (i.e., non-mechanized land preparation, traditional variety, low input). Base category for non-mechanized technologies is non-mechanized traditional low input, and for mechanized technologies is mechanized traditional low input. The switch is done when the farmer is no longer eligible for credit by the bank´s standard (i.e., below 1.75 times the farmer´s house value).

Table 85. CE* values (L.)* and IP for different technology categories, and credit and crop insurance use for farmers in Talanga and Guaimaca; with a RTP*** of 7%, insurance coverage of 45%, load=1.0, and two CRRAC****.**

Technology Category/credit and insurance	**Certainty Equivalent**		**Percent Insolvent**
	CRRAC=2	**CRRAC=4**	
Non-mechanized+traditional variety+low input use+no credit+no insurance	120,486	98,689	27.26%
Non-mechanized+traditional variety+high input use+no credit+no insurance	120,342	95,503	30.42%
Non-mechanized+modern variety+low input use+no credit+no insurance	120,082	96,392	29.62%
Non-mechanized+modern variety+high input use+no credit+no insurance	120,813	93,341	32.36%
Non-mechanized+modern variety+high input use+no credit+with insurance	119,978	93,682	32.88%
Non-mechanized+modern variety+high input use+with credit+with insurance (switch*****)	115,343	91,865	33.94%
Mechanized+traditional variety+low input use+no credit+no insurance	137,493	109,122	18.44%
Mechanized+traditional variety+high input use+no credit+no insurance	134,735	103,513	23.22%
Mechanized+modern variety+high input use+no credit+no insurance	130,898	98,133	28.12%
Mechanized+modern variety+high input use+no credit+with insurance	130,956	99,447	27.82%
Mechanized+modern variety+high input use+with credit+with insurance (switch)	132,504	101,562	25.82%

* CE=Certainty equivalent; L.=Lempira, Honduran currency.US $1=19.03 in 2007; **IP=insolvency percentage out of 5,000; Insolvent is a producer with an ending period wealth less than or equal to 1.25 times the house value. ; ***RTP=Rate of time preference; ****CRRAC=Constant relative risk aversion coefficient.

*****Switch refers to the farmer switching back from the actual technology category (e.g., non-mechanized land preparation, modern variety, high input) to base technology category (i.e., non-mechanized land preparation, traditional variety, low input). Base category for non-mechanized technologies is non-mechanized traditional low input, and for mechanized technologies is mechanized traditional low input. The switch is done when the farmer is no longer eligible for credit by the bank´s standard (i.e., below 1.75 times the farmer´s house value).

Table 86. CE* values (L.)* and IP for different technology categories, and credit and crop insurance use for farmers in Talanga and Guaimaca; with a RTP*** of 7%, insurance coverage of 45%, load=1.4, and two CRRAC****.**

Technology Category/credit and insurance	**Certainty Equivalent**		**Percent Insolvent**
	CRRAC=2	**CRRAC=4**	
Non-mechanized+traditional variety+low input use+no credit+no insurance	120,486	98,689	27.26%
Non-mechanized+traditional variety+high input use+no credit+no insurance	120,342	95,503	30.42%
Non-mechanized+modern variety+low input use+no credit+no insurance	122,082	96,392	29.62%
Non-mechanized+modern variety+high input use+no credit+no insurance	120,813	93,341	32.36%
Non-mechanized+modern variety+high input use+no credit+with insurance	118,747	92,965	33.62%
Non-mechanized+modern variety+high input use+with credit+with insurance (switch*****)	114,201	91,176	34.64%
Mechanized+traditional variety+low input use+no credit+no insurance	137,493	109,122	18.44%
Mechanized+traditional variety+high input use+no credit+no insurance	134,735	103,513	23.22%
Mechanized+modern variety+high input use+no credit+no insurance	130,898	98,133	28.12%
Mechanized+modern variety+high input use+no credit+with insurance	129,415	98,507	28.68%
Mechanized+modern variety+high input use+with credit+with insurance (switch)	130,979	100,507	26.58%

* CE=Certainty equivalent; L.=Lempira, Honduran currency.US $1=19.03 in 2007; **IP=insolvency percentage out of 5,000; Insolvent is a producer with an ending period wealth less than or equal to 1.25 times the house value. ; ***RTP=Rate of time preference; ****CRRAC=Constant relative risk aversion coefficient.

*****Switch refers to the farmer switching back from the actual technology category (e.g., non-mechanized land preparation, modern variety, high input) to base technology category (i.e., non-mechanized land preparation, traditional variety, low input). Base category for non-mechanized technologies is non-mechanized traditional low input, and for mechanized technologies is mechanized traditional low input. The switch is done when the farmer is no longer eligible for credit by the bank´s standard (i.e., below 1.75 times the farmer´s house value).

Table 87. CE* values (L.)* and IP for different technology categories, and credit and crop insurance use for farmers in Talanga and Guaimaca; with a RTP*** of 14%, insurance coverage of 75%, load=1.0, and two CRRAC****.**

Technology Category/credit and insurance	**Certainty Equivalent**		**Percent Insolvent**
	CRRAC=2	**CRRAC=4**	
Non-mechanized+traditional variety+low input use+no credit+no insurance	120,082	105,986	27.26%
Non-mechanized+traditional variety+high input use+no credit+no insurance	120,320	103,195	30.42%
Non-mechanized+modern variety+low input use+no credit+no insurance	121,928	104,153	29.62%
Non-mechanized+modern variety+high input use+no credit+no insurance	121,056	101,139	32.36%
Non-mechanized+modern variety+high input use+no credit+with insurance	122,215	105,587	31.46%
Non-mechanized+modern variety+high input use+with credit+with insurance (switch*****)	117,781	102,561	31.72%
Mechanized+traditional variety+low input use+no credit+no insurance	132,478	115,195	18.44%
Mechanized+traditional variety+high input use+no credit+no insurance	131,121	110,660	23.22%
Mechanized+modern variety+high input use+no credit+no insurance	129,155	105,955	28.12%
Mechanized+modern variety+high input use+no credit+with insurance	132,549	113,523	22.78%
Mechanized+modern variety+high input use+with credit+with insurance (switch)	133,294	114,804	19.36%

* CE=Certainty equivalent; L.=Lempira, Honduran currency.US $1=19.03 in 2007; **IP=insolvency percentage out of 5,000; Insolvent is a producer with an ending period wealth less than or equal to 1.25 times the house value. ; ***RTP=Rate of time preference; ****CRRAC=Constant relative risk aversion coefficient.

*****Switch refers to the farmer switching back from the actual technology category (e.g., non-mechanized land preparation, modern variety, high input) to base technology category (i.e., non-mechanized land preparation, traditional variety, low input). Base category for non-mechanized technologies is non-mechanized traditional low input, and for mechanized technologies is mechanized traditional low input. The switch is done when the farmer is no longer eligible for credit by the bank´s standard (i.e., below 1.75 times the farmer´s house value).

Table 88. CE* values (L.)* and IP for different technology categories, and credit and crop insurance use for farmers in Talanga and Guaimaca; with a RTP*** of 14%, insurance coverage of 75%, load=1.4, and two CRRAC****.**

Technology Category/credit and insurance	**Certainty Equivalent**		**Percent Insolvent**
	CRRAC=2	**CRRAC=4**	
Non-mechanized+traditional variety+low input use+no credit+no insurance	120,082	105,986	27.26%
Non-mechanized+traditional variety+high input use+no credit+no insurance	120,320	103,195	30.42%
Non-mechanized+modern variety+low input use+no credit+no insurance	121,928	104,153	29.62%
Non-mechanized+modern variety+high input use+no credit+no insurance	121,056	101,139	32.36%
Non-mechanized+modern variety+high input use+no credit+with insurance	117,855	101,972	35.56%
Non-mechanized+modern variety+high input use+with credit+with insurance (switch*****)	113,966	99,487	36.24%
Mechanized+traditional variety+low input use+no credit+no insurance	132,478	115,195	18.44%
Mechanized+traditional variety+high input use+no credit+no insurance	131,121	110,660	23.22%
Mechanized+modern variety+high input use+no credit+no insurance	129,155	105,955	28.12%
Mechanized+modern variety+high input use+no credit+with insurance	127,135	108,812	27.90%
Mechanized+modern variety+high input use+with credit+with insurance (switch)	128,109	110,325	24.64%

* CE=Certainty equivalent; L.=Lempira, Honduran currency.US $1=19.03 in 2007; **IP=insolvency percentage out of 5,000; Insolvent is a producer with an ending period wealth less than or equal to 1.25 times the house value. ; ***RTP=Rate of time preference; ****CRRAC=Constant relative risk aversion coefficient.
*****Switch refers to the farmer switching back from the actual technology category (e.g., non-mechanized land preparation, modern variety, high input) to base technology category (i.e., non-mechanized land preparation, traditional variety, low input). Base category for non-mechanized technologies is non-mechanized traditional low input, and for mechanized technologies is mechanized traditional low input. The switch is done when the farmer is no longer eligible for credit by the bank´s standard (i.e., below 1.75 times the farmer´s house value).

Table 89. CE* values (L.)* and IP for different technology categories, and credit and crop insurance use for farmers in Talanga and Guaimaca; with a RTP*** of 14%, insurance coverage of 45%, load=1.0, and two CRRAC****.**

Technology Category/credit and insurance	**Certainty Equivalent**		**Percent Insolvent**
	CRRAC=2	**CRRAC=4**	
Non-mechanized+traditional variety+low input use+no credit+no insurance	120,082	105,986	27.26%
Non-mechanized+traditional variety+high input use+no credit+no insurance	120,320	103,195	30.42%
Non-mechanized+modern variety+low input use+no credit+no insurance	121,928	104,153	29.62%
Non-mechanized+modern variety+high input use+no credit+no insurance	121,056	101,139	32.36%
Non-mechanized+modern variety+high input use+no credit+with insurance	120,736	101,860	32.88%
Non-mechanized+modern variety+high input use+with credit+with insurance (switch*****)	117,191	100,073	33.94%
Mechanized+traditional variety+low input use+no credit+no insurance	132,478	115,195	18.44%
Mechanized+traditional variety+high input use+no credit+no insurance	131,121	110,660	23.22%
Mechanized+modern variety+high input use+no credit+no insurance	129,159	105,955	28.12%
Mechanized+modern variety+high input use+no credit+with insurance	129,511	107,608	27.82%
Mechanized+modern variety+high input use+with credit+with insurance (switch)	130,788	109,575	25.82%

* CE=Certainty equivalent; L.=Lempira, Honduran currency.US $1=19.03 in 2007; **IP=insolvency percentage out of 5,000; Insolvent is a producer with an ending period wealth less than or equal to 1.25 times the house value. ; ***RTP=Rate of time preference; ****CRRAC=Constant relative risk aversion coefficient.

*****Switch refers to the farmer switching back from the actual technology category (e.g., non-mechanized land preparation, modern variety, high input) to base technology category (i.e., non-mechanized land preparation, traditional variety, low input). Base category for non-mechanized technologies is non-mechanized traditional low input, and for mechanized technologies is mechanized traditional low input. The switch is done when the farmer is no longer eligible for credit by the bank´s standard (i.e., below 1.75 times the farmer´s house value).

Table 90. CE* values (L.)* and IP for different technology categories, and credit and crop insurance use for farmers in Talanga and Guaimaca; with a RTP*** of 14%, insurance coverage of 45%, load=1.4, and two CRRAC****.**

Technology Category/credit and insurance	**Certainty Equivalent**		**Percent Insolvent**
	CRRAC=2	**CRRAC=4**	
Non-mechanized+traditional variety+low input use+no credit+no insurance	120,082	105,986	27.26%
Non-mechanized+traditional variety+high input use+no credit+no insurance	120,320	103,195	30.42%
Non-mechanized+modern variety+low input use+no credit+no insurance	121,928	104,153	29.62%
Non-mechanized+modern variety+high input use+no credit+no insurance	121,056	101,139	32.36%
Non-mechanized+modern variety+high input use+no credit+with insurance	119,747	101,132	33.62%
Non-mechanized+modern variety+high input use+with credit+with insurance (switch*****)	116,281	99,402	34.64%
Mechanized+traditional variety+low input use+no credit+no insurance	132,478	115,195	18.44%
Mechanized+traditional variety+high input use+no credit+no insurance	131,121	110,660	23.22%
Mechanized+modern variety+high input use+no credit+no insurance	129,155	105,955	28.12%
Mechanized+modern variety+high input use+no credit+with insurance	128,325	106,697	28.68%
Mechanized+modern variety+high input use+with credit+with insurance (switch)	129,637	108,687	26.58%

* CE=Certainty equivalent; L.=Lempira, Honduran currency.US $1=19.03 in 2007; **IP=insolvency percentage out of 5,000; Insolvent is a producer with an ending period wealth less than or equal to 1.25 times the house value. ; ***RTP=Rate of time preference; ****CRRAC=Constant relative risk aversion coefficient.

*****Switch refers to the farmer switching back from the actual technology category (e.g., non-mechanized land preparation, modern variety, high input) to base technology category (i.e., non-mechanized land preparation, traditional variety, low input). Base category for non-mechanized technologies is non-mechanized traditional low input, and for mechanized technologies is mechanized traditional low input. The switch is done when the farmer is no longer eligible for credit by the bank´s standard (i.e., below 1.75 times the farmer´s house value).

Table 91. CE* values (L.)* and IP for different technology categories, and credit and crop insurance use for farmers in Villa de San Francisco and Sabaneta de Valle de Angeles; with a RTP*** of 7%, insurance coverage of 75%, load=1.0, and two CRRAC****.**

Technology Category/credit and insurance	**Certainty Equivalent**		**Percent Insolvent**
	CRRAC=2	**CRRAC=4**	
Non-mechanized+traditional variety+low input use+no credit+no insurance	112,034	94,714	31.00%
Non-mechanized+traditional variety+high input use+no credit+no insurance	114,079	93,012	32.92%
Non-mechanized+modern variety+low input use+no credit+no insurance	117,502	94,910	30.86%
Non-mechanized+modern variety+high input use+no credit+no insurance	116,386	92,028	34.32%
Non-mechanized+modern variety+high input use+no credit+with insurance	116,643	95,198	33.48%
Non-mechanized+modern variety+high input use+with credit+with insurance (switch*****)	111,332	92,377	32.64%
Mechanized+traditional variety+low input use+no credit+no insurance	129,221	105,850	19.78%
Mechanized+traditional variety+high input use+no credit+no insurance	128,313	101,456	24.38%
Mechanized+modern variety+high input use+no credit+no insurance	127,462	97,207	29.04%
Mechanized+modern variety+high input use+no credit+with insurance	130,342	103,679	24.92%
Mechanized+modern variety+high input use+with credit+with insurance (switch)	131,697	105,650	20.90%

* CE=Certainty equivalent; L.=Lempira, Honduran currency.US $1=19.03 in 2007; **IP=insolvency percentage out of 5,000; Insolvent is a producer with an ending period wealth less than or equal to 1.25 times the house value. ; ***RTP=Rate of time preference; ****CRRAC=Constant relative risk aversion coefficient.

*****Switch refers to the farmer switching back from the actual technology category (e.g., non-mechanized land preparation, modern variety, high input) to base technology category (i.e., non-mechanized land preparation, traditional variety, low input). Base category for non-mechanized technologies is non-mechanized traditional low input, and for mechanized technologies is mechanized traditional low input. The switch is done when the farmer is no longer eligible for credit by the bank´s standard (i.e., below 1.75 times the farmer´s house value).

Table 92. CE* values (L.)* and IP for different technology categories, and credit and crop insurance use for farmers in Villa de San Francisco and Sabaneta de Valle de Angeles; with a RTP*** of 7%, insurance coverage of 75%, load=1.4, and two CRRAC****.**

Technology Category/credit and insurance	**Certainty Equivalent**		**Percent Insolvent**
	CRRAC=2	**CRRAC=4**	
Non-mechanized+traditional variety+low input use+no credit+no insurance	112,034	94,719	31.00%
Non-mechanized+traditional variety+high input use+no credit+no insurance	114,079	93,012	32.92%
Non-mechanized+modern variety+low input use+no credit+no insurance	117,502	94,910	30.86%
Non-mechanized+modern variety+high input use+no credit+no insurance	116,386	92,028	34.32%
Non-mechanized+modern variety+high input use+no credit+with insurance	111,977	91,972	37.24%
Non-mechanized+modern variety+high input use+with credit+with insurance (switch*****)	107,320	89,628	37.04%
Mechanized+traditional variety+low input use+no credit+no insurance	129,221	105,850	19.78%
Mechanized+traditional variety+high input use+no credit+no insurance	128,313	101,456	24.38%
Mechanized+modern variety+high input use+no credit+no insurance	127,462	97,207	29.04%
Mechanized+modern variety+high input use+no credit+with insurance	123,880	98,994	29.70%
Mechanized+modern variety+high input use+with credit+with insurance (switch)	125,282	100,926	25.54%

* CE=Certainty equivalent; L.=Lempira, Honduran currency.US $1=19.03 in 2007; **IP=insolvency percentage out of 5,000; Insolvent is a producer with an ending period wealth less than or equal to 1.25 times the house value. ; ***RTP=Rate of time preference; ****CRRAC=Constant relative risk aversion coefficient.

*****Switch refers to the farmer switching back from the actual technology category (e.g., non-mechanized land preparation, modern variety, high input) to base technology category (i.e., non-mechanized land preparation, traditional variety, low input). Base category for non-mechanized technologies is non-mechanized traditional low input, and for mechanized technologies is mechanized traditional low input. The switch is done when the farmer is no longer eligible for credit by the bank´s standard (i.e., below 1.75 times the farmer´s house value).

Table 93. CE* values (L.)* and IP for different technology categories, and credit and crop insurance use for farmers in Villa de San Francisco and Sabaneta de Valle de Angeles; with a RTP*** of 7%, insurance coverage of 45%, load=1.0, and two CRRAC****.**

Technology Category/credit and insurance	Certainty Equivalent		Percent Insolvent
	CRRAC=2	CRRAC=4	
Non-mechanized+traditional variety+low input use+no credit+no insurance	112,034	94,719	31.00%
Non-mechanized+traditional variety+high input use+no credit+no insurance	114,079	93,012	32.92%
Non-mechanized+modern variety+low input use+no credit+no insurance	117,502	94,910	30.86%
Non-mechanized+modern variety+high input use+no credit+no insurance	116,386	92,028	34.32%
Non-mechanized+modern variety+high input use+no credit+with insurance	115,836	92,432	34.64%
Non-mechanized+modern variety+high input use+with credit+with insurance (switch*****)	111,305	90,552	34.70%
Mechanized+traditional variety+low input use+no credit+no insurance	129,221	105,850	19.78%
Mechanized+traditional variety+high input use+no credit+no insurance	128,313	101,456	24.38%
Mechanized+modern variety+high input use+no credit+no insurance	127,462	97,207	29.04%
Mechanized+modern variety+high input use+no credit+with insurance	127,207	98,226	28.88%
Mechanized+modern variety+high input use+with credit+with insurance (switch)	128,709	100,254	25.94%

* CE=Certainty equivalent; L.=Lempira, Honduran currency.US $1=19.03 in 2007; **IP=insolvency percentage out of 5,000; Insolvent is a producer with an ending period wealth less than or equal to 1.25 times the house value. ; ***RTP=Rate of time preference; ****CRRAC=Constant relative risk aversion coefficient.
*****Switch refers to the farmer switching back from the actual technology category (e.g., non-mechanized land preparation, modern variety, high input) to base technology category (i.e., non-mechanized land preparation, traditional variety, low input). Base category for non-mechanized technologies is non-mechanized traditional low input, and for mechanized technologies is mechanized traditional low input. The switch is done when the farmer is no longer eligible for credit by the bank´s standard (i.e., below 1.75 times the farmer´s house value).

Table 94. CE* values (L.)* and IP for different technology categories, and credit and crop insurance use for farmers in Villa de San Francisco and Sabaneta de Valle de Angeles; with a RTP*** of 7%, insurance coverage of 45%, load=1.4, and two CRRAC****.**

Technology Category/credit and insurance	**Certainty Equivalent**		**Percent Insolvent**
	CRRAC=2	**CRRAC=4**	
Non-mechanized+traditional variety+low input use+no credit+no insurance	112,034	94,719	31.00%
Non-mechanized+traditional variety+high input use+no credit+no insurance	114,079	93,012	32.92%
Non-mechanized+modern variety+low input use+no credit+no insurance	117,502	94,910	30.86%
Non-mechanized+modern variety+high input use+no credit+no insurance	116,386	92,028	34.32%
Non-mechanized+modern variety+high input use+no credit+with insurance	114,778	91,791	35.42%
Non-mechanized+modern variety+high input use+with credit+with insurance (switch*****)	110,328	89,946	35.26%
Mechanized+traditional variety+low input use+no credit+no insurance	1292,221	105,850	19.78%
Mechanized+traditional variety+high input use+no credit+no insurance	128,313	101,456	24.38%
Mechanized+modern variety+high input use+no credit+no insurance	127,462	97,207	29.04%
Mechanized+modern variety+high input use+no credit+with insurance	125,724	97,313	29.62%
Mechanized+modern variety+high input use+with credit+with insurance (switch)	127,125	99,234	26.88%

* CE=Certainty equivalent; L.=Lempira, Honduran currency.US $1=19.03 in 2007; **IP=insolvency percentage out of 5,000; Insolvent is a producer with an ending period wealth less than or equal to 1.25 times the house value. ; ***RTP=Rate of time preference; ****CRRAC=Constant relative risk aversion coefficient.

*****Switch refers to the farmer switching back from the actual technology category (e.g., non-mechanized land preparation, modern variety, high input) to base technology category (i.e., non-mechanized land preparation, traditional variety, low input). Base category for non-mechanized technologies is non-mechanized traditional low input, and for mechanized technologies is mechanized traditional low input. The switch is done when the farmer is no longer eligible for credit by the bank´s standard (i.e., below 1.75 times the farmer´s house value).

Table 95. CE* values (L.)* and IP for different technology categories, and credit and crop insurance use for farmers in Villa de San Francisco and Sabaneta de Valle de Angeles; with a RTP*** of 14%, insurance coverage of 75%, load=1.0, and two CRRAC****.**

Technology Category/credit and insurance	Certainty Equivalent		Percent Insolvent
	CRRAC=2	CRRAC=4	
Non-mechanized+traditional variety+low input use+no credit+no insurance	113,672	102,395	31.00%
Non-mechanized+traditional variety+high input use+no credit+no insurance	115,381	100,833	32.92%
Non-mechanized+modern variety+low input use+no credit+no insurance	118,175	102,701	30.86%
Non-mechanized+modern variety+high input use+no credit+no insurance	117,530	99,921	34.32%
Non-mechanized+modern variety+high input use+no credit+with insurance	118,219	103,742	33.48%
Non-mechanized+modern variety+high input use+with credit+with insurance (switch*****)	114,219	100,744	32.64%
Mechanized+traditional variety+low input use+no credit+no insurance	126,208	112,132	19.78%
Mechanized+traditional variety+high input use+no credit+no insurance	126,182	108,647	24.38%
Mechanized+modern variety+high input use+no credit+no insurance	126,365	105,036	29.04%
Mechanized+modern variety+high input use+no credit+with insurance	129,158	111,615	24.92%
Mechanized+modern variety+high input use+with credit+with insurance (switch)	129,894	112,831	20.90%

* CE=Certainty equivalent; L.=Lempira, Honduran currency.US $1=19.03 in 2007; **IP=insolvency percentage out of 5,000; Insolvent is a producer with an ending period wealth less than or equal to 1.25 times the house value. ; ***RTP=Rate of time preference; ****CRRAC=Constant relative risk aversion coefficient.
*****Switch refers to the farmer switching back from the actual technology category (e.g., non-mechanized land preparation, modern variety, high input) to base technology category (i.e., non-mechanized land preparation, traditional variety, low input). Base category for non-mechanized technologies is non-mechanized traditional low input, and for mechanized technologies is mechanized traditional low input. The switch is done when the farmer is no longer eligible for credit by the bank´s standard (i.e., below 1.75 times the farmer´s house value).

Table 96. CE* values (L.)* and IP for different technology categories, and credit and crop insurance use for farmers in Villa de San Francisco and Sabaneta de Valle de Angeles; with a RTP*** of 14%, insurance coverage of 75%, load=1.4, and two CRRAC****.**

Technology Category/credit and insurance	**Certainty Equivalent**		**Percent Insolvent**
	CRRAC=2	**CRRAC=4**	
Non-mechanized+traditional variety+low input use+no credit+no insurance	113,676	102,395	31.00%
Non-mechanized+traditional variety+high input use+no credit+no insurance	115,381	100,833	32.92%
Non-mechanized+modern variety+low input use+no credit+no insurance	118,175	102,701	30.86%
Non-mechanized+modern variety+high input use+no credit+no insurance	117,530	99,921	34.32%
Non-mechanized+modern variety+high input use+no credit+with insurance	114,841	100,648	37.24%
Non-mechanized+modern variety+high input use+with credit+with insurance (switch*****)	111,008	98,136	37.04%
Mechanized+traditional variety+low input use+no credit+no insurance	126,208	112,132	19.78%
Mechanized+traditional variety+high input use+no credit+no insurance	126,182	108,647	24.38%
Mechanized+modern variety+high input use+no credit+no insurance	126,365	105,036	29.04%
Mechanized+modern variety+high input use+no credit+with insurance	124,352	107,424	29.70%
Mechanized+modern variety+high input use+with credit+with insurance (switch)	125,270	108,828	25.54%

* CE=Certainty equivalent; L.=Lempira, Honduran currency.US $1=19.03 in 2007; **IP=insolvency percentage out of 5,000; Insolvent is a producer with an ending period wealth less than or equal to 1.25 times the house value. ; ***RTP=Rate of time preference; ****CRRAC=Constant relative risk aversion coefficient.

*****Switch refers to the farmer switching back from the actual technology category (e.g., non-mechanized land preparation, modern variety, high input) to base technology category (i.e., non-mechanized land preparation, traditional variety, low input). Base category for non-mechanized technologies is non-mechanized traditional low input, and for mechanized technologies is mechanized traditional low input. The switch is done when the farmer is no longer eligible for credit by the bank´s standard (i.e., below 1.75 times the farmer´s house value).

Table 97. CE* values (L.)* and IP for different technology categories, and credit and crop insurance use for farmers in Villa de San Francisco and Sabaneta de Valle de Angeles; with a RTP*** of 14%, insurance coverage of 45%, load=1.0, and two CRRAC****.**

Technology Category/credit and insurance	Certainty Equivalent		Percent Insolvent
	CRRAC=2	CRRAC=4	
Non-mechanized+traditional variety+low input use+no credit+no insurance	113,672	102,395	31.00%
Non-mechanized+traditional variety+high input use+no credit+no insurance	115,381	100,833	32.92%
Non-mechanized+modern variety+low input use+no credit+no insurance	118,175	102,701	30.86%
Non-mechanized+modern variety+high input use+no credit+no insurance	117,530	99,921	34.32%
Non-mechanized+modern variety+high input use+no credit+with insurance	117,363	100,625	34.64%
Non-mechanized+modern variety+high input use+with credit+with insurance (switch*****)	113,814	98,709	34.70%
Mechanized+traditional variety+low input use+no credit+no insurance	126,208	112,132	19.78%
Mechanized+traditional variety+high input use+no credit+no insurance	126,182	108,647	24.38%
Mechanized+modern variety+high input use+no credit+no insurance	126,365	105,036	29.04%
Mechanized+modern variety+high input use+no credit+with insurance	126,488	106,398	28.88%
Mechanized+modern variety+high input use+with credit+with insurance (switch)	127,656	108,179	25.94%

* CE=Certainty equivalent; L.=Lempira, Honduran currency.US $1=19.03 in 2007; **IP=insolvency percentage out of 5,000; Insolvent is a producer with an ending period wealth less than or equal to 1.25 times the house value. ; ***RTP=Rate of time preference; ****CRRAC=Constant relative risk aversion coefficient.
*****Switch refers to the farmer switching back from the actual technology category (e.g., non-mechanized land preparation, modern variety, high input) to base technology category (i.e., non-mechanized land preparation, traditional variety, low input). Base category for non-mechanized technologies is non-mechanized traditional low input, and for mechanized technologies is mechanized traditional low input. The switch is done when the farmer is no longer eligible for credit by the bank´s standard (i.e., below 1.75 times the farmer´s house value).

Table 98. CE* values (L.)* and IP for different technology categories, and credit and crop insurance use for farmers in Villa de San Francisco and Sabaneta de Valle de Angeles; with a RTP*** of 14%, insurance coverage of 45%, load=1.4, and two CRRAC****.**

Technology Category/credit and insurance	Certainty Equivalent		Percent Insolvent
	CRRAC=2	CRRAC=4	
Non-mechanized+traditional variety+low input use+no credit+no insurance	113,672	102,395	31.00%
Non-mechanized+traditional variety+high input use+no credit+no insurance	115,381	100,833	32.92%
Non-mechanized+modern variety+low input use+no credit+no insurance	118,175	102,701	30.86%
Non-mechanized+modern variety+high input use+no credit+no insurance	117,530	99,921	34.32%
Non-mechanized+modern variety+high input use+no credit+with insurance	116,513	99,982	35.42%
Non-mechanized+modern variety+high input use+with credit+with insurance (switch*****)	113,027	98,112	35.26%
Mechanized+traditional variety+low input use+no credit+no insurance	126,208	112,132	19.78%
Mechanized+traditional variety+high input use+no credit+no insurance	126,182	108,647	24.38%
Mechanized+modern variety+high input use+no credit+no insurance	126,365	105,036	29.04%
Mechanized+modern variety+high input use+no credit+with insurance	125,331	105,500	29.62%
Mechanized+modern variety+high input use+with credit+with insurance (switch)	126,486	107,254	26.88%

* CE=Certainty equivalent; L.=Lempira, Honduran currency.US $1=19.03 in 2007; **IP=insolvency percentage out of 5,000; Insolvent is a producer with an ending period wealth less than or equal to 1.25 times the house value. ; ***RTP=Rate of time preference; ****CRRAC=Constant relative risk aversion coefficient.

*****Switch refers to the farmer switching back from the actual technology category (e.g., non-mechanized land preparation, modern variety, high input) to base technology category (i.e., non-mechanized land preparation, traditional variety, low input). Base category for non-mechanized technologies is non-mechanized traditional low input, and for mechanized technologies is mechanized traditional low input. The switch is done when the farmer is no longer eligible for credit by the bank´s standard (i.e., below 1.75 times the farmer´s house value).

Table 99. CE* values (L.)* and IP for different technology categories, and credit and crop insurance use for farmers in Alauca; with a RTP*** of 7%, insurance coverage of 75%, load=1.0, and two CRRAC****.**

Technology Category/credit and insurance	Certainty Equivalent		Percent Insolvent
	CRRAC=2	CRRAC=4	
Non-mechanized+traditional variety+low input use+no credit+no insurance	116,122	98,369	26.28%
Non-mechanized+traditional variety+high input use+no credit+no insurance	116,886	95,709	29.76%
Non-mechanized+modern variety+low input use+no credit+no insurance	122,133	98,366	27.48%
Non-mechanized+modern variety+high input use+no credit+no insurance	119,834	94,493	31.82%
Non-mechanized+modern variety+high input use+no credit+with insurance	120,970	98,794	29.44%
Non-mechanized+modern variety+high input use+with credit+with insurance (switch*****)	114,563	94,933	30.92%
Mechanized+traditional variety+low input use+no credit+no insurance	135,252	111,520	15.24%
Mechanized+traditional variety+high input use+no credit+no insurance	132,654	104,884	21.66%
Mechanized+modern variety+high input use+no credit+no insurance	132,227	100,378	26.22%
Mechanized+modern variety+high input use+no credit+with insurance	137,367	109,647	18.68%
Mechanized+modern variety+high input use+with credit+with insurance (switch)	138,363	111,337	15.64%

* CE=Certainty equivalent; L.=Lempira, Honduran currency.US $1=19.03 in 2007; **IP=insolvency percentage out of 5,000; Insolvent is a producer with an ending period wealth less than or equal to 1.25 times the house value. ; ***RTP=Rate of time preference; ****CRRAC=Constant relative risk aversion coefficient.
*****Switch refers to the farmer switching back from the actual technology category (e.g., non-mechanized land preparation, modern variety, high input) to base technology category (i.e., non-mechanized land preparation, traditional variety, low input). Base category for non-mechanized technologies is non-mechanized traditional low input, and for mechanized technologies is mechanized traditional low input. The switch is done when the farmer is no longer eligible for credit by the bank´s standard (i.e., below 1.75 times the farmer´s house value).

Table 100. CE* values (L.)* and IP for different technology categories, and credit and crop insurance use for farmers in Alauca; with a RTP*** of 7%, insurance coverage of 75%, load=1.4, and two CRRAC****.**

Technology Category/credit and insurance	Certainty Equivalent		Percent Insolvent
	CRRAC=2	CRRAC=4	
Non-mechanized+traditional variety+low input use+no credit+no insurance	116,122	98,369	26.28%
Non-mechanized+traditional variety+high input use+no credit+no insurance	116,886	95,709	29.76%
Non-mechanized+modern variety+low input use+no credit+no insurance	122,133	98,366	27.48%
Non-mechanized+modern variety+high input use+no credit+no insurance	119,834	94,493	31.82%
Non-mechanized+modern variety+high input use+no credit+with insurance	115,753	95,023	34.10%
Non-mechanized+modern variety+high input use+with credit+with insurance (switch*****)	110,118	91,791	35.42%
Mechanized+traditional variety+low input use+no credit+no insurance	135,252	111,520	15.24%
Mechanized+traditional variety+high input use+no credit+no insurance	132,654	104,884	21.66%
Mechanized+modern variety+high input use+no credit+no insurance	132,227	100,378	26.22%
Mechanized+modern variety+high input use+no credit+with insurance	130,090	104,036	24.18%
Mechanized+modern variety+high input use+with credit+with insurance (switch)	131,137	105,709	21.36%

* CE=Certainty equivalent; L.=Lempira, Honduran currency.US $1=19.03 in 2007; **IP=insolvency percentage out of 5,000; Insolvent is a producer with an ending period wealth less than or equal to 1.25 times the house value. ; ***RTP=Rate of time preference; ****CRRAC=Constant relative risk aversion coefficient.
*****Switch refers to the farmer switching back from the actual technology category (e.g., non-mechanized land preparation, modern variety, high input) to base technology category (i.e., non-mechanized land preparation, traditional variety, low input). Base category for non-mechanized technologies is non-mechanized traditional low input, and for mechanized technologies is mechanized traditional low input. The switch is done when the farmer is no longer eligible for credit by the bank´s standard (i.e., below 1.75 times the farmer´s house value).

Table 101. CE* values (L.)* and IP for different technology categories, and credit and crop insurance use for farmers in Alauca; with a RTP*** of 7%, insurance coverage of 45%, load=1.0, and two CRRAC****.**

Technology Category/credit and insurance	Certainty Equivalent		Percent Insolvent
	CRRAC=2	CRRAC=4	
Non-mechanized+traditional variety+low input use+no credit+no insurance	116,122	98,369	26.28%
Non-mechanized+traditional variety+high input use+no credit+no insurance	116,886	95,709	29.76%
Non-mechanized+modern variety+low input use+no credit+no insurance	122,133	98,366	27.48%
Non-mechanized+modern variety+high input use+no credit+no insurance	119,834	94,493	31.82%
Non-mechanized+modern variety+high input use+no credit+with insurance	119,365	95,096	32.10%
Non-mechanized+modern variety+high input use+with credit+with insurance (switch*****)	114,166	92,653	33.30%
Mechanized+traditional variety+low input use+no credit+no insurance	135,252	111,520	15.24%
Mechanized+traditional variety+high input use+no credit+no insurance	132,654	104,884	21.66%
Mechanized+modern variety+high input use+no credit+no insurance	132,227	100,378	26.22%
Mechanized+modern variety+high input use+no credit+with insurance	132,493	102,047	25.72%
Mechanized+modern variety+high input use+with credit+with insurance (switch)	133,876	104,065	23.64%

* CE=Certainty equivalent; L.=Lempira, Honduran currency.US $1=19.03 in 2007; **IP=insolvency percentage out of 5,000; Insolvent is a producer with an ending period wealth less than or equal to 1.25 times the house value. ; ***RTP=Rate of time preference; ****CRRAC=Constant relative risk aversion coefficient.

*****Switch refers to the farmer switching back from the actual technology category (e.g., non-mechanized land preparation, modern variety, high input) to base technology category (i.e., non-mechanized land preparation, traditional variety, low input). Base category for non-mechanized technologies is non-mechanized traditional low input, and for mechanized technologies is mechanized traditional low input. The switch is done when the farmer is no longer eligible for credit by the bank´s standard (i.e., below 1.75 times the farmer´s house value).

Table 102. CE* values (L.)* and IP for different technology categories, and credit and crop insurance use for farmers in Alauca; with a RTP*** of 7%, insurance coverage of 45%, load=1.4, and two CRRAC****.**

Technology Category/credit and insurance	**Certainty Equivalent**		**Percent Insolvent**
	CRRAC=2	**CRRAC=4**	
Non-mechanized+traditional variety+low input use+no credit+no insurance	116,122	98,369	26.28%
Non-mechanized+traditional variety+high input use+no credit+no insurance	116,886	95,709	29.76%
Non-mechanized+modern variety+low input use+no credit+no insurance	122,132	98,366	27.48%
Non-mechanized+modern variety+high input use+no credit+no insurance	119,834	94,493	31.82%
Non-mechanized+modern variety+high input use+no credit+with insurance	118,171	94,329	33.22%
Non-mechanized+modern variety+high input use+with credit+with insurance (switch*****)	113,123	91,987	34.14%
Mechanized+traditional variety+low input use+no credit+no insurance	135,252	111,520	15.24%
Mechanized+traditional variety+high input use+no credit+no insurance	132,654	104,884	21.66%
Mechanized+modern variety+high input use+no credit+no insurance	132,227	100,378	26.22%
Mechanized+modern variety+high input use+no credit+with insurance	130,875	101,007	26.64%
Mechanized+modern variety+high input use+with credit+with insurance (switch)	132,256	103,002	24.48%

* CE=Certainty equivalent; L.=Lempira, Honduran currency.US $1=19.03 in 2007; **IP=insolvency percentage out of 5,000; Insolvent is a producer with an ending period wealth less than or equal to 1.25 times the house value. ; ***RTP=Rate of time preference; ****CRRAC=Constant relative risk aversion coefficient.

*****Switch refers to the farmer switching back from the actual technology category (e.g., non-mechanized land preparation, modern variety, high input) to base technology category (i.e., non-mechanized land preparation, traditional variety, low input). Base category for non-mechanized technologies is non-mechanized traditional low input, and for mechanized technologies is mechanized traditional low input. The switch is done when the farmer is no longer eligible for credit by the bank´s standard (i.e., below 1.75 times the farmer´s house value).

Table 103. CE* values (L.)* and IP for different technology categories, and credit and crop insurance use for farmers in Alauca; with a RTP*** of 14%, insurance coverage of 75%, load=1.0, and two CRRAC****.**

Technology Category/credit and insurance	Certainty Equivalent		Percent Insolvent
	CRRAC=2	CRRAC=4	
Non-mechanized+traditional variety+low input use+no credit+no insurance	116,511	105,377	26.28%
Non-mechanized+traditional variety+high input use+no credit+no insurance	117,535	103,304	29.76%
Non-mechanized+modern variety+low input use+no credit+no insurance	121,554	105,813	27.48%
Non-mechanized+modern variety+high input use+no credit+no insurance	120,235	102,353	31.82%
Non-mechanized+modern variety+high input use+no credit+with insurance	121,789	106,967	29.44%
Non-mechanized+modern variety+high input use+with credit+with insurance (switch*****)	116,763	103,166	30.92%
Mechanized+traditional variety+low input use+no credit+no insurance	130,036	116,415	15.24%
Mechanized+traditional variety+high input use+no credit+no insurance	129,163	111,603	21.66%
Mechanized+modern variety+high input use+no credit+no insurance	129,783	108,010	26.22%
Mechanized+modern variety+high input use+no credit+with insurance	133,698	116,256	18.68%
Mechanized+modern variety+high input use+with credit+with insurance (switch)	134,153	117,172	15.64%

* CE=Certainty equivalent; L.=Lempira, Honduran currency.US $1=19.03 in 2007; **IP=insolvency percentage out of 5,000; Insolvent is a producer with an ending period wealth less than or equal to 1.25 times the house value. ; ***RTP=Rate of time preference; ****CRRAC=Constant relative risk aversion coefficient.

*****Switch refers to the farmer switching back from the actual technology category (e.g., non-mechanized land preparation, modern variety, high input) to base technology category (i.e., non-mechanized land preparation, traditional variety, low input). Base category for non-mechanized technologies is non-mechanized traditional low input, and for mechanized technologies is mechanized traditional low input. The switch is done when the farmer is no longer eligible for credit by the bank´s standard (i.e., below 1.75 times the farmer´s house value).

Table 104. CE* values (L.)* and IP for different technology categories, and credit and crop insurance use for farmers in Alauca; with a RTP*** of 14%, insurance coverage of 75%, load=1.4, and two CRRAC****.**

Technology Category/credit and insurance	**Certainty Equivalent**		**Percent Insolvent**
	CRRAC=2	**CRRAC=4**	
Non-mechanized+traditional variety+low input use+no credit+no insurance	116,511	105,377	26.28%
Non-mechanized+traditional variety+high input use+no credit+no insurance	117,535	103,304	29.76%
Non-mechanized+modern variety+low input use+no credit+no insurance	121,554	105,813	27.48%
Non-mechanized+modern variety+high input use+no credit+no insurance	129,235	102,353	31.82%
Non-mechanized+modern variety+high input use+no credit+with insurance	117,806	103,529	34.10%
Non-mechanized+modern variety+high input use+with credit+with insurance (switch*****)	113,301	100,283	35.42%
Mechanized+traditional variety+low input use+no credit+no insurance	130,036	116,415	15.24%
Mechanized+traditional variety+high input use+no credit+no insurance	129,173	111,603	21.66%
Mechanized+modern variety+high input use+no credit+no insurance	129,783	118,010	26.22%
Mechanized+modern variety+high input use+no credit+with insurance	128,612	111,647	24.18%
Mechanized+modern variety+high input use+with credit+with insurance (switch)	129,251	112,775	21.36%

* CE=Certainty equivalent; L.=Lempira, Honduran currency.US $1=19.03 in 2007; **IP=insolvency percentage out of 5,000; Insolvent is a producer with an ending period wealth less than or equal to 1.25 times the house value. ; ***RTP=Rate of time preference; ****CRRAC=Constant relative risk aversion coefficient.
*****Switch refers to the farmer switching back from the actual technology category (e.g., non-mechanized land preparation, modern variety, high input) to base technology category (i.e., non-mechanized land preparation, traditional variety, low input). Base category for non-mechanized technologies is non-mechanized traditional low input, and for mechanized technologies is mechanized traditional low input. The switch is done when the farmer is no longer eligible for credit by the bank´s standard (i.e., below 1.75 times the farmer´s house value).

Table 105. CE* values (L.)* and IP for different technology categories, and credit and crop insurance use for farmers in Alauca; with a RTP*** of 14%, insurance coverage of 45%, load=1.0, and two CRRAC****.**

Technology Category/credit and insurance	Certainty Equivalent		Percent Insolvent
	CRRAC=2	CRRAC=4	
Non-mechanized+traditional variety+low input use+no credit+no insurance	116,511	105,377	26.28%
Non-mechanized+traditional variety+high input use+no credit+no insurance	117,535	103,304	29.76%
Non-mechanized+modern variety+low input use+no credit+no insurance	121,554	105,813	27.48%
Non-mechanized+modern variety+high input use+no credit+no insurance	129,235	102,353	31.82%
Non-mechanized+modern variety+high input use+no credit+with insurance	120,183	103,277	32.10%
Non-mechanized+modern variety+high input use+with credit+with insurance (switch*****)	116,135	100,839	33.30%
Mechanized+traditional variety+low input use+no credit+no insurance	130,083	116,415	15.24%
Mechanized+traditional variety+high input use+no credit+no insurance	129,173	111,603	21.66%
Mechanized+modern variety+high input use+no credit+no insurance	129,783	108,010	26.22%
Mechanized+modern variety+high input use+no credit+with insurance	130,275	109,925	25.72%
Mechanized+modern variety+high input use+with credit+with insurance (switch)	131,317	111,646	23.64%

* CE=Certainty equivalent; L.=Lempira, Honduran currency.US $1=19.03 in 2007; **IP=insolvency percentage out of 5,000; Insolvent is a producer with an ending period wealth less than or equal to 1.25 times the house value. ; ***RTP=Rate of time preference; ****CRRAC=Constant relative risk aversion coefficient.
*****Switch refers to the farmer switching back from the actual technology category (e.g., non-mechanized land preparation, modern variety, high input) to base technology category (i.e., non-mechanized land preparation, traditional variety, low input). Base category for non-mechanized technologies is non-mechanized traditional low input, and for mechanized technologies is mechanized traditional low input. The switch is done when the farmer is no longer eligible for credit by the bank´s standard (i.e., below 1.75 times the farmer´s house value).

Table 106. CE* values (L.)* and IP for different technology categories, and credit and crop insurance use for farmers in Alauca; with a RTP*** of 14%, insurance coverage of 45%, load=1.4, and two CRRAC****.**

Technology Category/credit and insurance	**Certainty Equivalent**		**Percent Insolvent**
	CRRAC=2	**CRRAC=4**	
Non-mechanized+traditional variety+low input use+no credit+no insurance	116,511	105,377	26.28%
Non-mechanized+traditional variety+high input use+no credit+no insurance	117,535	103,304	29.76%
Non-mechanized+modern variety+low input use+no credit+no insurance	121,554	105,813	27.48%
Non-mechanized+modern variety+high input use+no credit+no insurance	129,235	102,353	31.82%
Non-mechanized+modern variety+high input use+no credit+with insurance	119,257	102,547	33.22%
Non-mechanized+modern variety+high input use+with credit+with insurance (switch*****)	115,308	100,198	34.14%
Mechanized+traditional variety+low input use+no credit+no insurance	130,036	116,415	15.24%
Mechanized+traditional variety+high input use+no credit+no insurance	129,173	111,603	21.66%
Mechanized+modern variety+high input use+no credit+no insurance	129,783	108,010	26.22%
Mechanized+modern variety+high input use+no credit+with insurance	129,062	108,951	26.64%
Mechanized+modern variety+high input use+with credit+with insurance (switch)	130,131	110,691	24.48%

* CE=Certainty equivalent; L.=Lempira, Honduran currency.US $1=19.03 in 2007; **IP=insolvency percentage out of 5,000; Insolvent is a producer with an ending period wealth less than or equal to 1.25 times the house value. ; ***RTP=Rate of time preference; ****CRRAC=Constant relative risk aversion coefficient.

*****Switch refers to the farmer switching back from the actual technology category (e.g., non-mechanized land preparation, modern variety, high input) to base technology category (i.e., non-mechanized land preparation, traditional variety, low input). Base category for non-mechanized technologies is non-mechanized traditional low input, and for mechanized technologies is mechanized traditional low input. The switch is done when the farmer is no longer eligible for credit by the bank´s standard (i.e., below 1.75 times the farmer´s house value).

Table 107. CE* values (L.)* and IP for different technology categories, and credit and crop insurance use for farmers in Arauli and Chirinos; with a RTP*** of 7%, insurance coverage of 75%, load=1.0, and two CRRAC****.**

Technology Category/credit and insurance	**Certainty Equivalent**		**Percent Insolvent**
	CRRAC=2	**CRRAC=4**	
Non-mechanized+traditional variety+low input use+no credit+no insurance	109,837	94,599	30.40%
Non-mechanized+traditional variety+high input use+no credit+no insurance	109,877	91,953	34.60%
Non-mechanized+modern variety+low input use+no credit+no insurance	115,305	95,078	30.82%
Non-mechanized+modern variety+high input use+no credit+no insurance	112,937	91,355	35.06%
Non-mechanized+modern variety+high input use+no credit+with insurance	112,516	93,985	35.08%
Non-mechanized+modern variety+high input use+with credit+with insurance (switch*****)	107,038	90,718	35.42%
Mechanized+traditional variety+low input use+no credit+no insurance	126,951	106,400	18.78%
Mechanized+traditional variety+high input use+no credit+no insurance	124,201	100,425	24.96%
Mechanized+modern variety+high input use+no credit+no insurance	124,277	97,027	28.78%
Mechanized+modern variety+high input use+no credit+with insurance	127,040	103,721	24.20%
Mechanized+modern variety+high input use+with credit+with insurance (switch)	128,314	105,611	19.44%

* CE=Certainty equivalent; L.=Lempira, Honduran currency.US $1=19.03 in 2007; **IP=insolvency percentage out of 5,000; Insolvent is a producer with an ending period wealth less than or equal to 1.25 times the house value. ; ***RTP=Rate of time preference; ****CRRAC=Constant relative risk aversion coefficient.
*****Switch refers to the farmer switching back from the actual technology category (e.g., non-mechanized land preparation, modern variety, high input) to base technology category (i.e., non-mechanized land preparation, traditional variety, low input). Base category for non-mechanized technologies is non-mechanized traditional low input, and for mechanized technologies is mechanized traditional low input. The switch is done when the farmer is no longer eligible for credit by the bank´s standard (i.e., below 1.75 times the farmer´s house value).

Table 108. CE* values (L.)* and IP for different technology categories, and credit and crop insurance use for farmers in Arauli and Chirinos; with a RTP*** of 7%, insurance coverage of 75%, load=1.4, and two CRRAC****.**

Technology Category/credit and insurance	**Certainty Equivalent**		**Percent Insolvent**
	CRRAC=2	**CRRAC=4**	
Non-mechanized+traditional variety+low input use+no credit+no insurance	109,837	94,599	30.40%
Non-mechanized+traditional variety+high input use+no credit+no insurance	109,877	91,953	34.60%
Non-mechanized+modern variety+low input use+no credit+no insurance	115,305	95,078	30.82%
Non-mechanized+modern variety+high input use+no credit+no insurance	112,937	91,355	35.06%
Non-mechanized+modern variety+high input use+no credit+with insurance	107,769	90,541	39.50%
Non-mechanized+modern variety+high input use+with credit+with insurance (switch*****)	103,119	87,958	40.04%
Mechanized+traditional variety+low input use+no credit+no insurance	126,951	106,400	18.78%
Mechanized+traditional variety+high input use+no credit+no insurance	124,201	100,425	24.96%
Mechanized+modern variety+high input use+no credit+no insurance	124,277	97,027	28.78%
Mechanized+modern variety+high input use+no credit+with insurance	120,518	98,691	29.90%
Mechanized+modern variety+high input use+with credit+with insurance (switch)	121,916	100,619	25.46%

* CE=Certainty equivalent; L.=Lempira, Honduran currency.US $1=19.03 in 2007; **IP=insolvency percentage out of 5,000; Insolvent is a producer with an ending period wealth less than or equal to 1.25 times the house value. ; ***RTP=Rate of time preference; ****CRRAC=Constant relative risk aversion coefficient.

*****Switch refers to the farmer switching back from the actual technology category (e.g., non-mechanized land preparation, modern variety, high input) to base technology category (i.e., non-mechanized land preparation, traditional variety, low input). Base category for non-mechanized technologies is non-mechanized traditional low input, and for mechanized technologies is mechanized traditional low input. The switch is done when the farmer is no longer eligible for credit by the bank´s standard (i.e., below 1.75 times the farmer´s house value).

Table 109. CE* values (L.)* and IP for different technology categories, and credit and crop insurance use for farmers in Arauli and Chirinos; with a RTP*** of 7%, insurance coverage of 45%, load=1.0, and two CRRAC****.**

Technology Category/credit and insurance	**Certainty Equivalent**		**Percent Insolvent**
	CRRAC=2	**CRRAC=4**	
Non-mechanized+traditional variety+low input use+no credit+no insurance	109,837	94,599	30.40%
Non-mechanized+traditional variety+high input use+no credit+no insurance	109,877	91,953	34.60%
Non-mechanized+modern variety+low input use+no credit+no insurance	115,305	95,078	30.82%
Non-mechanized+modern variety+high input use+no credit+no insurance	112,937	91,355	35.06%
Non-mechanized+modern variety+high input use+no credit+with insurance	112,208	91,629	35.82%
Non-mechanized+modern variety+high input use+with credit+with insurance (switch*****)	107,490	89,379	36.50%
Mechanized+traditional variety+low input use+no credit+no insurance	126,951	106,400	18.78%
Mechanized+traditional variety+high input use+no credit+no insurance	124,201	100,425	24.96%
Mechanized+modern variety+high input use+no credit+no insurance	124,277	97,027	28.78%
Mechanized+modern variety+high input use+no credit+with insurance	123,901	97,996	28.98%
Mechanized+modern variety+high input use+with credit+with insurance (switch)	125,303	99,959	26.18%

* CE=Certainty equivalent; L.=Lempira, Honduran currency.US $1=19.03 in 2007; **IP=insolvency percentage out of 5,000; Insolvent is a producer with an ending period wealth less than or equal to 1.25 times the house value. ; ***RTP=Rate of time preference; ****CRRAC=Constant relative risk aversion coefficient.

*****Switch refers to the farmer switching back from the actual technology category (e.g., non-mechanized land preparation, modern variety, high input) to base technology category (i.e., non-mechanized land preparation, traditional variety, low input). Base category for non-mechanized technologies is non-mechanized traditional low input, and for mechanized technologies is mechanized traditional low input. The switch is done when the farmer is no longer eligible for credit by the bank´s standard (i.e., below 1.75 times the farmer´s house value).

Table 110. CE* values (L.)* and IP for different technology categories, and credit and crop insurance use for farmers in Arauli and Chirinos; with a RTP*** of 7%, insurance coverage of 45%, load=1.4, and two CRRAC****.**

Technology Category/credit and insurance	**Certainty Equivalent**		**Percent Insolvent**
	CRRAC=2	**CRRAC=4**	
Non-mechanized+traditional variety+low input use+no credit+no insurance	109,837	94,599	30.40%
Non-mechanized+traditional variety+high input use+no credit+no insurance	109,877	91,953	34.60%
Non-mechanized+modern variety+low input use+no credit+no insurance	115,305	95,078	30.82%
Non-mechanized+modern variety+high input use+no credit+no insurance	112,937	91,355	35.06%
Non-mechanized+modern variety+high input use+no credit+with insurance	111,081	90,895	36.78%
Non-mechanized+modern variety+high input use+with credit+with insurance (switch*****)	106,524	88,758	37.64%
Mechanized+traditional variety+low input use+no credit+no insurance	126,951	106,400	18.78%
Mechanized+traditional variety+high input use+no credit+no insurance	124,201	100,425	24.96%
Mechanized+modern variety+high input use+no credit+no insurance	124,277	97,027	28.78%
Mechanized+modern variety+high input use+no credit+with insurance	122,406	97,016	30.04%
Mechanized+modern variety+high input use+with credit+with insurance (switch)	123,837	98,960	27.14%

* CE=Certainty equivalent; L.=Lempira, Honduran currency.US $1=19.03 in 2007; **IP=insolvency percentage out of 5,000; Insolvent is a producer with an ending period wealth less than or equal to 1.25 times the house value. ; ***RTP=Rate of time preference; ****CRRAC=Constant relative risk aversion coefficient.

*****Switch refers to the farmer switching back from the actual technology category (e.g., non-mechanized land preparation, modern variety, high input) to base technology category (i.e., non-mechanized land preparation, traditional variety, low input). Base category for non-mechanized technologies is non-mechanized traditional low input, and for mechanized technologies is mechanized traditional low input. The switch is done when the farmer is no longer eligible for credit by the bank´s standard (i.e., below 1.75 times the farmer´s house value).

Table 111. CE* values (L.)* and IP for different technology categories, and credit and crop insurance use for farmers in Arauli and Chirinos; with a RTP*** of 14%, insurance coverage of 75%, load=1.0, and two CRRAC****.**

Technology Category/credit and insurance	Certainty Equivalent		Percent Insolvent
	CRRAC=2	CRRAC=4	
Non-mechanized+traditional variety+low input use+no credit+no insurance	111,868	102,195	30.40%
Non-mechanized+traditional variety+high input use+no credit+no insurance	112,051	99,877	34.60%
Non-mechanized+modern variety+low input use+no credit+no insurance	116,399	102,892	30.82%
Non-mechanized+modern variety+high input use+no credit+no insurance	114,684	99,275	35.06%
Non-mechanized+modern variety+high input use+no credit+with insurance	115,245	102,583	35.08%
Non-mechanized+modern variety+high input use+with credit+with insurance (switch*****)	110,741	99,199	35.42%
Mechanized+traditional variety+low input use+no credit+no insurance	124,328	112,323	18.78%
Mechanized+traditional variety+high input use+no credit+no insurance	123,010	107,700	24.96%
Mechanized+modern variety+high input use+no credit+no insurance	123,592	104,804	28.78%
Mechanized+modern variety+high input use+no credit+with insurance	126,324	111,382	24.20%
Mechanized+modern variety+high input use+with credit+with insurance (switch)	126,905	112,379	19.44%

* CE=Certainty equivalent; L.=Lempira, Honduran currency.US $1=19.03 in 2007; **IP=insolvency percentage out of 5,000; Insolvent is a producer with an ending period wealth less than or equal to 1.25 times the house value. ; ***RTP=Rate of time preference; ****CRRAC=Constant relative risk aversion coefficient.

*****Switch refers to the farmer switching back from the actual technology category (e.g., non-mechanized land preparation, modern variety, high input) to base technology category (i.e., non-mechanized land preparation, traditional variety, low input). Base category for non-mechanized technologies is non-mechanized traditional low input, and for mechanized technologies is mechanized traditional low input. The switch is done when the farmer is no longer eligible for credit by the bank´s standard (i.e., below 1.75 times the farmer´s house value).

Table 112. CE* values (L.)* and IP for different technology categories, and credit and crop insurance use for farmers in Arauli and Chirinos; with a RTP*** of 14%, insurance coverage of 75%, load=1.4, and two CRRAC****.**

Technology Category/credit and insurance	Certainty Equivalent		Percent Insolvent
	CRRAC=2	CRRAC=4	
Non-mechanized+traditional variety+low input use+no credit+no insurance	111,868	102,195	30.40%
Non-mechanized+traditional variety+high input use+no credit+no insurance	112,051	99,877	34.60%
Non-mechanized+modern variety+low input use+no credit+no insurance	116,399	102,892	30.82%
Non-mechanized+modern variety+high input use+no credit+no insurance	114,684	99,275	35.06%
Non-mechanized+modern variety+high input use+no credit+with insurance	111,483	99,344	39.50%
Non-mechanized+modern variety+high input use+with credit+with insurance (switch*****)	107,560	96,562	40.04%
Mechanized+traditional variety+low input use+no credit+no insurance	124,328	112,323	18.78%
Mechanized+traditional variety+high input use+no credit+no insurance	123,010	107,700	24.96%
Mechanized+modern variety+high input use+no credit+no insurance	123,592	104,804	28.78%
Mechanized+modern variety+high input use+no credit+with insurance	121,534	107,049	29.90%
Mechanized+modern variety+high input use+with credit+with insurance (switch)	122,348	108,313	25.46%

* CE=Certainty equivalent; L.=Lempira, Honduran currency.US $1=19.03 in 2007; **IP=insolvency percentage out of 5,000; Insolvent is a producer with an ending period wealth less than or equal to 1.25 times the house value. ; ***RTP=Rate of time preference; ****CRRAC=Constant relative risk aversion coefficient.
*****Switch refers to the farmer switching back from the actual technology category (e.g., non-mechanized land preparation, modern variety, high input) to base technology category (i.e., non-mechanized land preparation, traditional variety, low input). Base category for non-mechanized technologies is non-mechanized traditional low input, and for mechanized technologies is mechanized traditional low input. The switch is done when the farmer is no longer eligible for credit by the bank´s standard (i.e., below 1.75 times the farmer´s house value).

Table 113. CE* values (L.)* and IP for different technology categories, and credit and crop insurance use for farmers in Arauli and Chirinos; with a RTP*** of 14%, insurance coverage of 45%, load=1.0, and two CRRAC****.**

Technology Category/credit and insurance	**Certainty Equivalent**		**Percent Insolvent**
	CRRAC=2	**CRRAC=4**	
Non-mechanized+traditional variety+low input use+no credit+no insurance	111,868	102,195	30.40%
Non-mechanized+traditional variety+high input use+no credit+no insurance	112,051	99,877	34.60%
Non-mechanized+modern variety+low input use+no credit+no insurance	116,399	102,892	30.82%
Non-mechanized+modern variety+high input use+no credit+no insurance	114,684	99,275	35.06%
Non-mechanized+modern variety+high input use+no credit+with insurance	114,430	99,874	35.82%
Non-mechanized+modern variety+high input use+with credit+with insurance (switch*****)	110,685	97,607	36.50%
Mechanized+traditional variety+low input use+no credit+no insurance	124,328	112,323	18.78%
Mechanized+traditional variety+high input use+no credit+no insurance	123,010	107,700	24.96%
Mechanized+modern variety+high input use+no credit+no insurance	123,592	104,804	28.78%
Mechanized+modern variety+high input use+no credit+with insurance	123,696	106,156	28.98%
Mechanized+modern variety+high input use+with credit+with insurance (switch)	124,738	107,785	26.18%

* CE=Certainty equivalent; L.=Lempira, Honduran currency.US $1=19.03 in 2007; **IP=insolvency percentage out of 5,000; Insolvent is a producer with an ending period wealth less than or equal to 1.25 times the house value. ; ***RTP=Rate of time preference; ****CRRAC=Constant relative risk aversion coefficient.

*****Switch refers to the farmer switching back from the actual technology category (e.g., non-mechanized land preparation, modern variety, high input) to base technology category (i.e., non-mechanized land preparation, traditional variety, low input). Base category for non-mechanized technologies is non-mechanized traditional low input, and for mechanized technologies is mechanized traditional low input. The switch is done when the farmer is no longer eligible for credit by the bank´s standard (i.e., below 1.75 times the farmer´s house value).

Table 114. CE* values (L.)* and IP for different technology categories, and credit and crop insurance use for farmers in Arauli and Chirinos; with a RTP*** of 14%, insurance coverage of 45%, load=1.4, and two CRRAC****.**

Technology Category/credit and insurance	**Certainty Equivalent**		**Percent Insolvent**
	CRRAC=2	**CRRAC=4**	
Non-mechanized+traditional variety+low input use+no credit+no insurance	111,868	102,195	30.40%
Non-mechanized+traditional variety+high input use+no credit+no insurance	112,051	99,877	34.60%
Non-mechanized+modern variety+low input use+no credit+no insurance	116,399	102,892	30.82%
Non-mechanized+modern variety+high input use+no credit+no insurance	114,684	99,275	35.06%
Non-mechanized+modern variety+high input use+no credit+with insurance	113,535	99,183	36.78%
Non-mechanized+modern variety+high input use+with credit+with insurance (switch*****)	109,917	97,018	37.64%
Mechanized+traditional variety+low input use+no credit+no insurance	124,328	102,323	18.78%
Mechanized+traditional variety+high input use+no credit+no insurance	123,010	107,700	24.96%
Mechanized+modern variety+high input use+no credit+no insurance	123,592	104,804	28.78%
Mechanized+modern variety+high input use+no credit+with insurance	122,541	105,218	30.04%
Mechanized+modern variety+high input use+with credit+with insurance (switch)	123,636	106,900	27.14%

* CE=Certainty equivalent; L.=Lempira, Honduran currency.US $1=19.03 in 2007; **IP=insolvency percentage out of 5,000; Insolvent is a producer with an ending period wealth less than or equal to 1.25 times the house value. ; ***RTP=Rate of time preference; ****CRRAC=Constant relative risk aversion coefficient.

*****Switch refers to the farmer switching back from the actual technology category (e.g., non-mechanized land preparation, modern variety, high input) to base technology category (i.e., non-mechanized land preparation, traditional variety, low input). Base category for non-mechanized technologies is non-mechanized traditional low input, and for mechanized technologies is mechanized traditional low input. The switch is done when the farmer is no longer eligible for credit by the bank´s standard (i.e., below 1.75 times the farmer´s house value).

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