ABSTRACT

ARRIAGADA, RODRIGO ANTONIO. Estimating profitability and fertilizer demand for rice production around the Palo Verde National Park, Costa Rica. (Under the direction of Dr. Fred Cubbage and Dr. Erin Sills).

Rice cultivation is intensively cultivated in some regions of Costa Rica thanks to the establishment of several irrigation projects. This is especially important for the case of several agricultural communities that cultivate their land around the Palo Verde National Park, where the development of the Arenal-Tempisque Irrigation project has brought prosperity to the local farmers.

This study made a detailed description of the current rice production system used around Palo Verde by identifying the variable and fixed inputs involved in the rice production. This study included household information of three agricultural settlements. This research also included the estimation of a profit function associated with rice production in this area and the estimation of a fertilizer demand function. Risk analysis was also included to analyze different policy scenarios and determine future fertilizer consumption.

Throughout the statistical description of the current rice production system, no statistically significant differences where found among the three communities included.

The estimated profit function determined that seed price and capital intensity are significant whereas for the case of the fertilizer demand function rice production, seed price and fertilizer price resulted to be significant.

Risk analysis showed the important impact of the current tariff application on imported rice on profits.

Regarding the different policy scenarios evaluated to discourage the fertilizer use in this region of Costa Rica, direct intervention on fertilizer price (tax application) has the greatest impact on reduction of fertilizer consumption.

Results of the risk analysis concluded that no future changes in fertilizer demand associated with rice production should be expected in this area.

ESTIMATING PROFITABILITY AND FERTILIZER DEMAND FOR RICE PRODUCTION AROUND THE PALO VERDE NATIONAL PARK, COSTA RICA

by
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DEDICATION

To my lovely wife who gave me
the strengths to pursue this dream

BIOGRAPHY

Rodrigo Antonio Arriagada Cisternas was born in Santiago in 1972. He finished high school at Instituto Nacional Jose Miguel Carrera in Santiago. He always demonstrated an interest on nature, and his continuous effort made him to obtain his professional title in Forest Engineering and his Bachelor in Forest Engineering at the University of Chile

After graduating he worked for two years in projects related to environmental and sustainable development, focused to help small organizations to establish foundations on their own business. Due all projects developed with his partners, who also graduated from University of Chile, they felt the inspiration to create a consultant company called FORESMAN Inc. After this commitment, they started to develop projects with international fund as UNDP and OAS.

Rodrigo also worked for the Chilean government at the Ministry of Education for two years, in a program called MESESUP, created especially for the improvement of the quality of the Chilean Higher Education. Due to the successful and positive results in Chile through those years working with educational projects, he decided to continue his studies at the Department of Forestry at North Carolina State University in the United States, leaving his home country three days after getting married to Ana Maria Araos, in August of 2002. She has been his companion and support during these two years as a Master's student in Natural Resources.

In 2003 he visited the National Park of Palo Verde, Costa Rica, working with rice farmers to study the impacts of the biggest irrigation system of this beautiful country.

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1. Introduction

1.1. Objective of the study

The Arenal-Tempisque watershed is located in northwestern Costa Rica and is one of the most economically productive regions of the country. The irrigation district associated with this watershed is also the largest in the country and the premier producer of rice and sugarcane.

However, the introduction of irrigation water to the Guanacaste Province, as a result of the Arenal-Tempisque Irrigation Project, is having a major impact on land use in the province. As an example, agricultural development is expected to expand by over 10,000 hectares in just the next two years.

One example of the agricultural expansion is the rice production around the Palo Verde National Park, which is located on the Pacific slopes of Guanacaste Province in northwestern Costa Rica, and is characterized for being the major bird sanctuary in Central America and the host to thousands of migratory birds flying between the north and the south.

Currently, there is no information about the relationship among rice cultivation, local economy and environment in this region of Costa Rica. Specifically, the details of the current rice production and its level of profitability are unknown. It is also unknown if profitability varies among farmers in this area and its determinants. No specific information exists about specific environmental impacts of the use of pesticides, herbicides and fertilizers, and the variables that explain their demand.

Farmers demand for the highly intensive use of fertilizers is also unknown in this area. The intensive use of agrochemicals represents one of the main environmental disservices that affect the wetlands of Palo Verde.

This study aims to describe quantitatively the profitability of the rice production around Palo Verde and its associated fertilizer demand. This information will add important information for the formulation of future policies that seek a more efficient use of the land and promote a more environmentally friendly agriculture in this particular region of Costa Rica

Regarding the research questions, this study is concentrated on the next questions:

- What is the typical rice farmer?
- What are the differences among farmers?
- What drives the level of profits at the micro level?
- What is the impact of the Costa Rican rice trade policy?
- What drives the level of fertilizers use?
- What are the policy levers that seek the reduction of fertilizer consumption?

1.2. Structure of the study

This study will be structured on four chapters:

- Chapter 1: Introductory chapter.
- Chapter 2: Rice production around Palo Verde, Costa Rica: costs and returns.
- Chapter 3: Econometric analysis of profitability associated with rice production around Palo Verde, Costa Rica.
- Chapter 4: Estimation of a fertilizer demand function associated with rice production around Palo Verde, Costa Rica.

These chapters will include the next activities:

- Define a profit and a fertilizer demand function using several key variables that are believed impact profit and fertilizer use (e.g. material costs, labor, yield, rice price, etc.).
- Using simulation and risk analysis, we can estimate future profits and fertilizer demand given probability distribution of key variables that can influence both elements.
- Given that 100% of the farmers are receiving irrigation and this is fomenting a great development of rice production, we could value the environmental cost associated with the highly intensive use of fertilizers.
- Another important public cost that we can measure is the application of rice price tariffs. Using Monte Carlo simulation and the probability distribution of international rice prices we could estimate the profits that these farmers would receive in the future facing the international rice price instead of the domestic rice price.

On Chapter 2 information will be produced on costs and revenues associated with the rice production in the five agrarian communities included in this study (Bagatzi, Falconiana, La Soga, San Ramon and Playitas). These results will permit make conclusions about the profitability of the rice cultivations and the differences among the communities.

Chapter 3 and 4 seek to define a functional form that can represent profits and fertilizer demand in this area. These results will give important information about the variables that influence the level of profitability and the use of fertilizers associated with the production of rice around Palo Verde.

Chapter 3 and 4, using function estimation results and risk analysis, also seek to anticipate profits and fertilizer consumption under several scenarios. Policy implications will be discussed.

2. Rice production around Palo Verde, Costa Rica: costs and returns

2.1. Introduction

Rice is a basic ingredient of the Costa Rican diet. Its cultivation started as a rudimentary activity, but the development of a better support's infrastructure (introduction of new seeds, technical assistance, better cultivation techniques, etc.) has changed its dynamic. Now the rice cultivation is much more intensive, especially in the areas with availability of irrigation water.

The Guanacaste Province is one of the areas has enjoyed the benefits of irrigation through the establishment of the Arenal-Tempisque Irrigation Project (PRAT). This particular irrigation program increased the reliability of the water supply, which in turn enabled farmers to move from one to two crops per year, resulting in a significant increase in land productivity and contributing to national food security (Hazell, 2001).

Bagatzi, Falconiana, La Soga, San Ramon and Playitas are agricultural communities located around the Palo Verde National Park in the Guanacaste Province. These five communities have enjoyed the benefits of PRAT fomenting the establishment of more intensive rice cultivation.

This chapter presents a detailed description of the rice production associated with these five communities. Information on input costs and output production was collected with the purpose of describing the current system of rice production and the profitability associated with it in this particular area. Statistical tests were designed to check differences among farmers of the different communities included. Special emphasis was made in the use of agrochemicals which represent a high percentage of the total costs involved in the rice production.

2.2 Study area

The area selected in this study is located in the Province of Guanacaste, a part of the Chorotega Region Costa Rica. This province is located to the north of the country with a total population of 264,238 inhabitants according with the census completed on 2000. Of this total, 41.9% are located on urban areas and 58.1% on rural areas. The agriculture sector has the largest number of workers with a 28% of the economically active population which accounts for 90,395 people. Figure 2.1 shows a map of the Guanacaste Province where Palo Verde is located.

Figure 2.1. Map of the Guanacaste Province Costa Rica

This region is particularly important due to its economic activities. Tourism, aquaculture, sugar cane and rice plantations have brought prosperity and employment to the area. Specifically, the Guanacaste province is the main rice production zone of the country. During the period 2000-2001, the rice purchases of industrial companies from producers of Guanacaste was 136,283 metric tons, which represents 52.16% of the total rice purchase in Costa Rica (Ministry of Agriculture, 2003).

The Chorotega region also has the highest level of precipitation intensity in Costa Rica, an average of 200 mm/hour, a dry season of six months that combined with fires decreases the vegetation cover and increases the risk of soil erosion.

The Palo Verde National Park is located on the Pacific slopes of Guanacaste. It includes 20,000-hectare park with a seasonally dry forest on limestone outcrops and extensive wetland vegetation bordering the Tempisque River that flows into the Gulf of Nicoya. The Tempisque and Bebedero watersheds represent 10% of the country, 53% of the Guanacaste Province, and 45% of the national rice production.

The Tempisque river basin has been the site of important biophysical, productive and social transformations over the last five centuries, which have shaped it into a complex matrix of agricultural lands, wetlands, protected areas and human settlements (Jimenez et al editors, 2001).

Currently, the introduction of irrigation water into the Guanacaste Province is a result of the Arenal-Tempisque Irrigation Project (PRAT). This project was conceived between 1975 and 1978 and is administered by the National Service of Subterranean Waters, Irrigation and Drainage (SENARA). In total, close to 20,000 hectares are currently under irrigation benefiting close to 800 producers. Small farmers that work on 7 to 10 hectares pieces of land manage more than 50% of this area. A total of 234 kilometers of channels have built, as well as 89 kilometers of drainage canals and 230 kilometers of roads and paths (Jimenez et al editors, 2001).

2.2.1. *Soil characteristics*

In Costa Rica, the rice cultivation is located on soils with medium to high level of fertility and flat slopes. The soils are represented in three orders: Vertisoles, Mollisoles and Inceptisoles (Cordero, 1984 cited by Perez, 2002). For the case of the Tempisque River basin and the Arenal-Tempisque irrigation project, the Vertisoles represents more than 40% of the total area under cultivation (Table 2.1).

Table 2.1. Distribution of Rice cultivation in the Tempisque river basin according to soil order

	Tempisque River Basin		Arenal-Tempisque Irrigation District	
Soil order	(ha)	%	(ha)	%
Vertisoles	15,951	39.0	8,160	47.5
Inceptisoles	10,634	26.0	1,018	5.9
Mollisoles	9,445	23.1	5,944	34.6
Alfisoles	1,449	3.5	706	4.1
Inceptisoles/Entisoles	1,413	3.5	724	4.2
Entisoles/Inceptisoles	1,018	2.5	-	-
Entisoles	950	2.3	613	3.6
Totals	40,860		17,166	

Source: Organization for Tropical Studies (OTS), 2002

The Vertisoles soils, especially on tropical regions, represent edafic resources with a high value. The main features of these soils are its high level of natural fertility and its high capabilities to retain water (Comerma, 1985).

2.3. Survey design

As part of this study, structured interviews were developed between June and July of 2003 by the author. Five agricultural communities located around the Palo Verde National Park were selected and the male head of each household included in this survey was interviewed.

The farming system used in three of these communities (Bagatzi, Falconiana and La Soga) is representative of the system used by other farmers in the Guanacaste Province. Farmers of the other two communities (San Ramon and Playitas) use a farming system that is representative of the farming system used by private companies on that region. The farmers of these five communities are also beneficiaries of the Arenal-Tempisque irrigation project.

Using an adaptation of the agricultural section of the Living Standards Measurement Study (LSMS) that the World Bank uses for household surveys, a questionnaire was designed to interview the male head of the households included in this study. This survey instrument was developed based on previous experiences of the World Bank on countries similar to Costa Rica (e.g. Nicaragua and Panama). The questionnaire was also reviewed by two local field technicians who work with the OTS and have extensive field experience working with rice farmers in the area. Appendix 6.1 shows the questionnaire that was used to collect the data.

Once finished the field questionnaire, this was pre-tested to check the answers and include additional questions if necessary.

Data of the agricultural production unit, the rice production practices, the chemical inputs use, the labor allocation and the farm incomes was collected. Information on the level of technical assistance provided and credits used was also included. All this information was processed in the field station of the OTS located inside Palo Verde.

To select the interviews, the author of this study visited the five agricultural communities on a regular basis (every week at random times) during two months. Thanks to the high concentration of homes in these communities, during the visits, the farmers who were founded in their homes were interviewed. The total population in these five communities, and according with the information provided by OTS, include to 336 farming households.

Table 2.2 shows a summary of the questionnaire that was administered on the field. This questionnaire included structured questions about the agricultural production unit, outputs and inputs, expenses in agricultural activities, labor, technical assistance, agricultural assets and loans.

Table 2.2. Information included on the field interviews

Part A: Information about the agricultural production unit

- In the last 12 months, did you cultivate land of you?
- If you own land, how many own plots of land do you cultivate the last 12 months?
- In the last 12 months, did you cultivate rented, shared or borrowed land?
- How many rented, shared or borrowed plots did you cultivate the last 12 months?
- If you own land, what is the area of your parcel?
- Own land area under irrigation
- Own land area given to other for cultivating it
- What do you receive for giving to other your land?
- The last 12 months, how much money did you receive for the land given to other for cultivating it?
- Sum of rented, shared or borrowed plots area
- For renting land, how do you pay?

Part B: Agricultural activities

- In the last 12 months, what was the area cultivated?
- In the last 12 months, how many times did you harvest and what amount was harvested?
- What was the price of the last harvest and how much money did you receive for that harvest?
- In the last harvest, what amount of crop harvested did you keep for other uses?
- In the last harvest, what amount of cultivated crop did you lose?

Part C: Inputs

- Seed quantity used and money spent in seeds in the last harvest
- Quantity and money spent in fertilizers in the last harvest
- Money spent in insecticides, herbicides and fungicides in the last harvest

Part D: Expenses in agricultural activities

- Money spent in transport in the last harvest
- Money spent in renting machinery in the last harvest
- Land taxes, irrigation payment, crop insurance, other

Part E: Labor force

- In the last harvest, did you hire wage laborers for some agricultural tasks?
- Total sum of money used for hiring wage workers in the last harvest?
- In the last harvest, do family workers (including you) help to cultivate the crop?
- Family labor value

Part F: Technical assistance

- In the last 12 months, did you receive technical assistance?
- Who did provide the technical assistance in the last 12 months?
- How much money did you pay for technical assistance in the last harvest?
- What kind of technical assistance did you receive?

Part G: Agricultural assets and loans

- Do you own any agricultural equipment?
- Total sum of current value of agricultural equipments?
- In the last 12 months, did you receive any loan to finance your agricultural expenses?
- Who did give you the loan and how did you receive the loan?
- How much money did you receive for the loan?
- How much did you pay or will pay for the loan?
- What was the interest rate and what is the deadline for paying the loan?

2.4. Farm profile

2.4.1. *Farm size and tenure*

The average farm size included in this survey was 8.62 hectares. San Ramon and Playitas had the biggest average farm size (11.72 hectares) whereas Falconiana had the smallest farm size with 6.46 hectares (Table 2.3). 90.4% of the land included in this survey received irrigation water from the Arenal-Tempisque irrigation project, and everyone in this group received water irrigation from the PRAT.

Table 2.3. Number of farmers interviewed and average size plot

Community	Number of interviews	Average size plot (ha)*	Total land area (ha)**
Bagatzi	22	9.18	328.75
Falconiana	12	6.46	116.1
La Soga	13	7.03	157.48
San Ramon and Playitas	11	11.72	128.95
Totals	58	8.62	731.28

*Only includes the average size of plots owned by every farmer included in this survey
**Includes parcels of land owned and rented for every farmer included in this survey

Of the total land area included in this study, 518.00 ha (70.83%) are covered by rice. This percentage varies across the five communities: Bagatzi 260.25 ha (79.16%), Falconiana 78.50 ha (67.61%), La Soga 112.50 ha (71.44%), and San Ramon and Playitas 66.75 ha (51.76%). The rest of the area is covered mainly by sugar cane, watermelon and pasture. These features are represented in Figure 2.2. San Ramon and Playitas are considered together due to their close proximity and because these two communities use a different pattern of rice production in relation with the other three.

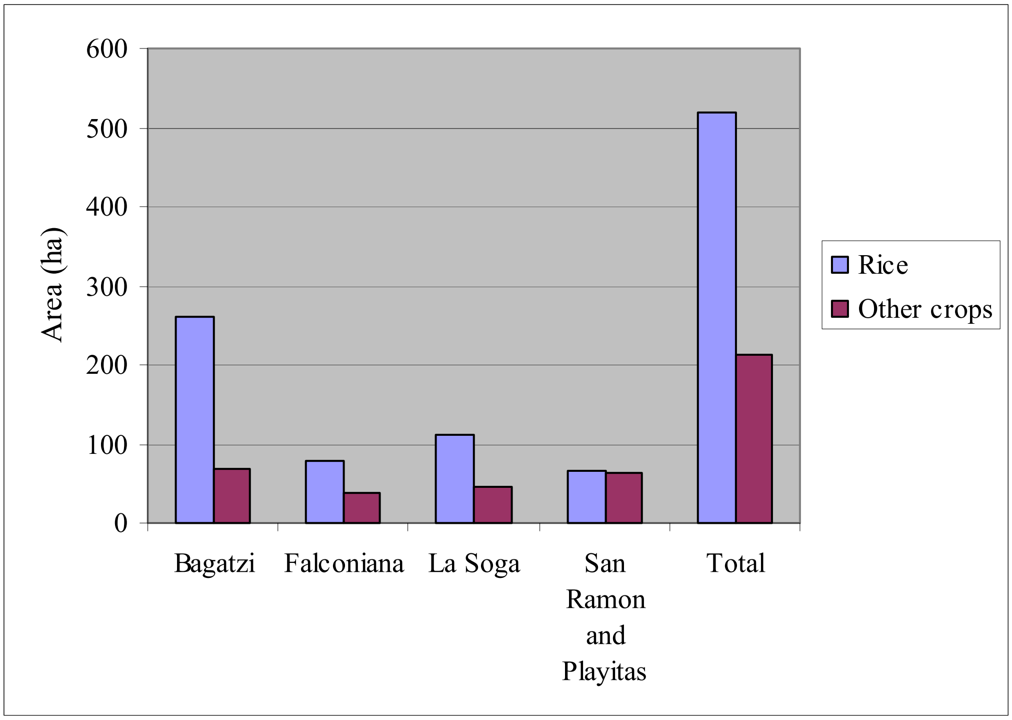

Figure 2.2. Land use distribution among farms of every community included in the survey

The Institute for the Agrarian Development (IDA), a governmental institution, has a program to promote the formation of human settlements on rural locations. The farmers that live in the communities and were included in this survey have received their lands from IDA with the only condition being that they must live in the settlement. The farmers receive their titles according with the Costa Rican legislation without including the possibility of selling the land.

IDA selects the farmers that can receive the land according with a list of requirements that each applicant must meet (the main requisites include the obligation of being married and without previous property on any land).

2.4.2. *Rice production system*

Rice is grown twice a year thanks to the PRAT. Mechanized land preparation and harvesting represent the common techniques used among farmers to cultivate the rice. The use of agrochemicals (fertilizers, pesticides and herbicides) is highly intensive. Four fertilizations of approximately 184 kilograms per hectare are applied during the rice cultivation. Nitrogen, phosphorus, potassium and zinc constitute the principal chemicals applied during the fertilizations. To control pests and common diseases, the use of chemicals is also intensive mainly due to the high pest susceptibility of the seeds varieties used in this area. The doses, application period and type of pesticides vary depending on the specific product applied (Perez, 2002).

The total duration of each cycle is around five months, depending basically on the variety of the seed. Table 2.4 shows the different activities involved in rice production from the land preparation to the harvesting. During the dry season the sowing is developed in December and during the rainy season in June-July.

Table 2.4. Activities developed during the rice production cycle

Activity	Month 1	Month 2	Month 3	Month 4	Month 5
Land preparation	*				
Sowing	*				
First fertilization	*				
Second fertilization	*				
Third fertilization		*			
Fourth fertilization		*			
Pest control	*	*	*	*	*
Maintenance	*	*	*	*	*
Harvesting					*

Two systems of rice production are found in this region. One is less mechanized but starts with mechanical soil preparation, the other is generally more mechanized, even including airplane seeding and fertilization, but does not require mechanical soil preparation.

Farmers in Bagatzi, Falconiana and La Soga use the less mechanized farming system where land preparation includes a mechanized activity called *fangueo* where a tractor is used to mix the soil on a wet condition with the purpose of controlling weeds and impeding water filtration. Every farmer applies the agro chemicals by his own or hires non-family workers to apply fertilizers, pesticides, herbicides, insecticides, and also for seeding. Technical assistance is provided by professionals that work for agricultural cooperatives, the National Institute of Insurance or the National Bank of Costa Rica depending if the farmer works with financial loans (one of the requirement to receive a credit is to have technical assistance and purchase crop insurance).

Farmers in San Ramon and Playitas use the more mechanized rice production system that does not include the *fangueo* and includes a mechanized seeding on a dry condition. The use of chemicals is also intensive and their application is highly mechanized with the use of airplanes and tractors. The machinery (tractors, airplanes, sower machines) is provided by the local private company that works with these farmers through an agreement with them (land owners cede their lands to the company during the rice season and farmers receive a proportion of the harvest revenue after covering all the costs expended by the company). In this case, the labor is supplied by the private company and sometimes the owner of the land is not involved at all; but other times, especially for the maintenance activities, the farmer can be hired to work on his or her own land. This is a labor agreement that can be established at the beginning of every season between the farmer and the company.

2.5. Rice inputs and costs

In the rice production several variables and fixed inputs are involved. The variable inputs include seeds, fertilizers, pesticides, herbicides, harvest transportation, labor and machinery. The fixed inputs include irrigation and land, and sometimes also include technical assistance, financial costs and crop insurance. For the area included in this survey Table 2.5 shows the different categories of inputs to produce rice and their overall averages estimated with the information provided by the farmers during the interviewing period.

Table 2.5. Overall average for the variables and fixed inputs involved in the rice production around Palo Verde. Estimates were calculated based on the information provided by the farmers included in this study

Variable inputs	Unit	Overall average*
Seed	Quintals**/ha	3.98
Fertilizer	Quintals/ha	10.52
Pesticide and herbicide cost	Colones***/ha	39,374
Harvest transportation cost	Colones/ha	16,798
Hired labor	Colones/ha	11,762
Machinery cost	Colones/ha	68,122
Fixed inputs		
Irrigation	Colones/ha	8,959
Land	Ha	8.29
Technical assistance	Colones/ha	2,244
Financial costs	Colones/ha	162,566
Crop insurance	Colones/ha	8,911

* Based on information collected from 40 households
**1 quintal = 46 kilograms
***1¢ = 1 Colon= 0.00234390 USD

Table 2.5 shows the average costs of technical assistance, financial cost and crop insurance. In general, farmers are obligated to incur in these costs when using financial loans.

Seeds and fertilizer constitutes the main inputs used to cultivate rice in this region. Their more or less intensive use determines the final results farmers can obtain in terms of rice production. The following pages show the descriptive statistics associated to seeds and fertilizer, then it shows the rest of the material cost involved in rice production including labor.

The descriptive statistics of the average use of seeds and fertilizer in the communities included in this study is shown in Table 2.6. The average rates of seeds used during the sowing season were between 4.06 and 3.85 quintals per hectare (not including farmers of San Ramon and Playitas).

According with Table 2.5, average cost of hired labor is 11,762 Colones per hectare with a coefficient of variation close to 84%. This high variation in hired labor among farmers is explained by the intensive use of agrochemicals, especially pesticides, which are very demanding of labor and can vary widely among farmers (the use of pesticides is more intensive when the crop is affected by a disease or a pathogen than when the crop is healthier).

Appendix 6.2 shows the bivariate correlation matrix among the inputs included in the rice production around Palo Verde. It is interesting to note that the use of fertilizers is highly correlated with the use of pesticides and herbicides.

The differences among the communities in terms of input use were tested using simple t-tests and related statistics. The data analysis option of Microsoft Excel was used to perform the analysis.

The difference in seeds used among farmers of Bagatzi, Falconiana and La Soga was not statistically significant at the 95% confidence level (Tables 2.7, 2.8 and 2.9). The average rates of fertilizers used during the rice season were between 9.03 and 11.18 quintals per hectare (not including farmers of San Ramon and Playitas). The difference in level of fertilizers used by farmers in Bagatzi, Falconiana and La Soga was not statistically significant at the 95% confidence level (Tables 2.10, 2.11 and 2.12). Given the close proximity of these three communities and considering that production technology is quite similar between farmers these results are according with it was expected.

Table 2.6: Descriptive statistics of seed and fertilizer use

Inputs		Agricultural community*		
		Bagatzi	Falconiana	La Soga
Seeds	Mean (quintal** ha^{-1})	4.06	3.98	3.85
	Std. Dev.	0.16	0.30	0.36
	CV(%)	4.11	7.63	9.37
	Minimum	3.70	3.50	3.00
	Maximum	4.50	4.60	4.30
	75th percentile	4.05	4.00	4.00
	25th percentile	4.00	3.95	3.70
Fertilizers	Mean (quintal ha^{-1})	10.73	9.03	11.18
	Std. Dev.	2.17	3.47	3.71
	CV(%)	20.25	38.48	33.26
	Minimum	6.30	2.00	6.00
	Maximum	15.00	12.7	18.00
	75th percentile	12.00	10.8	13.10
	25th percentile	9.30	8.4	8.00

* Based on information collected from 40 households
**1 quintal= 46 kilograms

Table 2.6 does not include San Ramon and Playitas because the land of these farmers is administered and managed by a private company and is not cultivated directly by the farmers. The private company basically follows the same production system for every farmer without variation. For the case of seeds and fertilizers, 4.68 quintals of seeds per hectare and 7.5 quintals of fertilizers per hectare are applied to every parcel.

Table 2.7. t-Test: two-sample assuming unequal variances for use of seeds among farmers of Bagatzi and Falconiana

	Bagatzi	Falconiana
Mean (quintal ha^{-1})	4.06	3.98
Variance	0.02	0.09
Observations	20	8
Hypothesized Mean Difference	0	
Df	9	
t Stat	0.63	
P(T<=t) two-tail	0.54	

Table 2.8. t-Test: two-sample assuming unequal variances for use of seeds among farmers of Bagatzi and La Soga

	Bagatzi	La Soga
Mean (quintal ha^{-1})	4.06	3.85
Variance	0.02	0.13
Observations	20	12
Hypothesized Mean Difference	0	
Df	14	
t Stat	1.89	
P(T<=t) two-tail	0.07	

Table 2.9. t-Test: two-sample assuming unequal variances for use of seeds among farmers of Falconiana and La Soga

	Falconiana	La Soga
Mean (quintal ha^{-1})	3.98	3.85
Variance	0.09	0.13
Observations	8	12
Hypothesized Mean Difference	0	
Df	17	
t Stat	0.91	
P(T<=t) two-tail	0.37	

Table 2.10. t-Test: two-sample assuming unequal variances for use of fertilizers among farmers of Bagatzi and Falconiana

	Bagatzi	Falconiana
Mean (quintal ha^{-1})	10.73	9.03
Variance	4.72	12.09
Observations	20	8
Hypothesized Mean Difference	0	
Df	9	
t Stat	1.28	
P(T<=t) two-tail	0.23	

Table 2.11. t-Test: two-sample assuming unequal variances for use of fertilizers among farmers of Bagatzi and La Soga

	Bagatzi	La Soga
Mean (quintal ha^{-1})	10.73	11.18
Variance	4.72	13.83
Observations	20	12
Hypothesized Mean Difference	0	
Df	16	
t Stat	-0.38	
P(T<=t) two-tail	0.70	

Table 2.12. t-Test: two-sample assuming unequal variances for use of fertilizers among farmers of Falconiana and La Soga

	Falconiana	La Soga
Mean (quintal ha^{-1})	9.03	11.18
Variance	12.09	13.83
Observations	8	12
Hypothesized Mean Difference	0	
Df	16	
t Stat	-1.31	
P(T<=t) two-tail	0.20	

The difference with San Ramon and Playitas was tested using a z-test where farmers of Bagatzi, Falconiana and La Soga were treated as one group (Table 2.13). The hypothesized means used for this test were the average mean of seeds and fertilizers used by farmers of San Ramon and Playitas (4.68 quintals of seeds per hectare and 7.5 quintals of fertilizers per hectare respectively). For the case of the level of seeds used, the test did provide strong evidence to reject the hypothesis therefore there is a statistically significant difference among the five communities (P-value = 0.00). For the case of the level of fertilizers, the test also found strong evidence to reject the hypothesis, showing a difference between San Ramon and Playitas, and the other three communities (P-value = 0.00). Farmers in these two communities are assisted directly by a private company. This company tends to apply fertilizers at a lower level with the idea of keeping the variable costs at a reasonable rate and because they have better information related with the appropriate quantities of fertilizers that have to be applied during the rice cultivation. Regarding the use of seeds, the method used in San Ramon and Playitas differs from the methods used in the other three communities. In this case, the sowing is mechanized and developed on a dry soil.

Farmers of Bagatzi, Falconiana and La Soga tend to apply higher levels of fertilizers. For this three communities, 25% apply less than 8.9 quintal ha^{-1} (lower quartile of the histogram showed in Figure 2.3). For the case of seeds used during sowing, only 25% of farmers used less than 4 quintals ha^{-1} whereas only 25% of farmers used more than 4 quintals ha^{-1} with a maximum of 4.6 quintal ha^{-1} as is the case of Falconiana (lower and upper quartile are equal as it is shown on Figure 2.4).

Table 2.13. Significance test for population mean use of seeds and fertilizers

	Bagatzi, Falconiana and La Soga	
	Seeds	Fertilizers
Number of cases	40	40
Mean (quintals ha^{-1})	3.98	10.52
SD	0.27	2.99
P-value	0.00*	0.00**

*It provides strong evidence to reject the hypothesis (H_o=4.68 quintals ha^{-1})
** It provides strong evidence to reject the hypothesis (H_o=7.5 quintals ha^{-1})

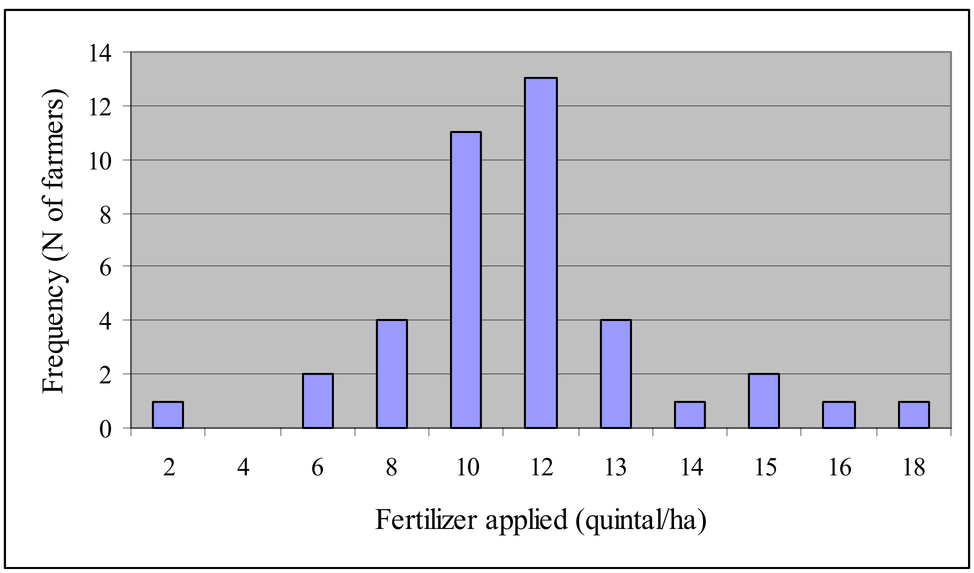

Figure 2.3. Frequency distribution of levels of fertilizer used in Bagatzi, Falconiana and La Soga

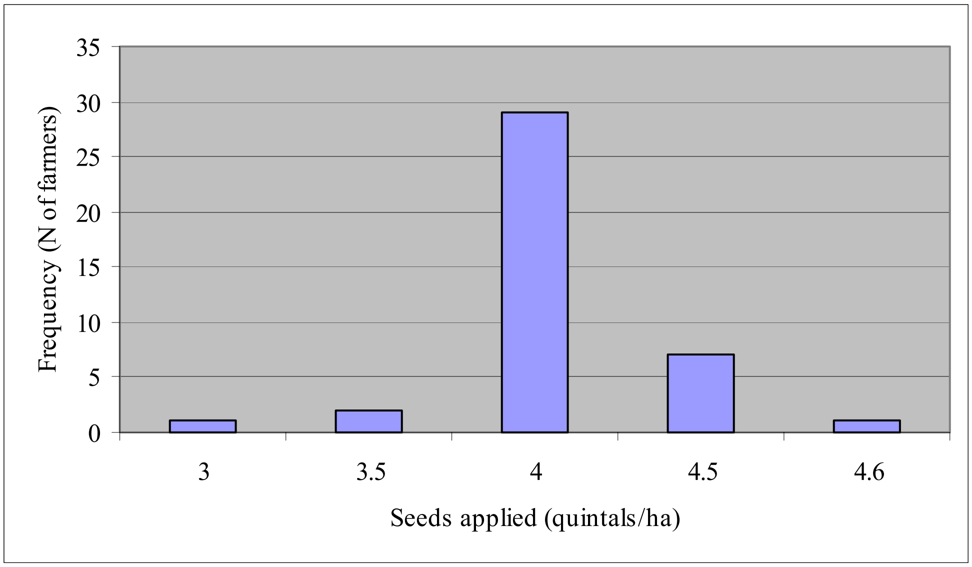

Figure 2.4. Frequency distribution of levels of seeds used in Bagatzi, Falconiana and La Soga

In the second rice season of 2003, the average material cost was ¢220,011 ha^{-1} for the case of Bagatzi, ¢178,581 ha^{-1} for Falconiana, and ¢226,242 ha^{-1} for La Soga (Table 2.14). These material costs included seeds, fertilizers, pesticides and herbicides, harvest transportation, and machinery rent because these costs are considered the main material costs involved in rice cultivation.

For Bagatzi, rented machinery is the major material cost and accounts for 31% of the total material cost. This situation is the same for Falconiana where rented machinery now represents about 34% of the total material cost. For farmers of la Soga the situation is also the same and the rented machinery cost represents about 32% of the total material cost. Given the highly mechanized rice production system, used for the farmers included in this survey (without including San Ramon and Playitas), is highly popular the use of tractors for land preparation, mechanized harvesters and trucks to transport the rice. All these services are provided by several other farmers that own these resources or are provided by local people that work renting these services. During the rice season the offer of these services is high enough to cover the demand of every farmer and is no a limitation to produce rice.

For the case of farmers in San Ramon and Playitas, the cost of seeds is ¢42,485 ha^{-1}, fertilization is ¢26,344 ha^{-1}, ¢80,719 ha^{-1} for the use of pesticides and herbicides, ¢11,336 ha^{-1} for transport and ¢131,389 ha^{-1} for machinery rent. These costs accounts for a total material cost of 292,273 ha^{-1}. The higher costs are explained by the different technological package used to produce rice. The highly intensive use of herbicides, insecticides and fungicides explain the high costs of pesticides and herbicides. In general there is also a more intensive use of better products associated with a high level of efficiency that increase even more the total costs of these products. There is a more intensive use of tractors and planes to apply agrochemicals and the use of sowing machines. In this case, machinery renting costs represents about 45% of the total material cost. The transport costs are less because these farmers give their harvest to a local private company which is located right next to these two communities.

Another important variable cost involved in rice production in Costa Rica is the hired labor costs. There are several activities, that depending on the household composition (number of adults men specially), are absorbed by off-farm laborers specially hired to complete these tasks. These laborers are also farmers of other households or people that come from Bagaces, Cañas or others close towns during the high labor demand season (specially during the sowing season and fertilizers application season).

Table 2.14 shows the average costs involved in hiring laborers during the rice season. The coefficient of variation is high for the three communities. This variation is explained because many activities are developed by members of the household without the need of hiring external workers. Table 2.14 shows only the cost of hiring these external workers without including the family labor. This average cost was calculated based on the different activities and the average rate of payment that every external work receives. In general the application of agrochemicals represents the major cost and also includes sowing, irrigation management and maintenance activities. Another important factor that affects the variation in the use of hired labor is the presence of pests and diseases in the crop. Given that the only method used to control pests and diseases is the chemical application of specific products, the appearance of these problems can greatly increase the cost of hired labor due to the necessity of additional chemical applications.

Table 2.14. Average material costs (Colones ha^{-1} at constant 2003 prices)

Material costs (¢** ha^{-1})		Agricultural community*		
		Bagatzi	Falconiana	La Soga
Seeds	Mean	40,177	38,240	37,225
	Std. Dev.	3,364	1,818	4,777
	CV(%)	8.38	13.45	12.83
	Minimum	27,640	27,640	27,750
	Maximum	43,940	46,000	43,450
	75th percentile	42,000	40,000	40,200
	25th percentile	40,000	37,087	35,420
Fertilizers	Mean	53,544	41,160	51,304
	Std. Dev.	12,506	16,533	16,070
	CV(%)	23.36	40.17	31.32
	Minimum	36,650	8,300	30,300
	Maximum	76,326	60,000	81,000
	75th percentile	60,487	51,750	57,250
	25th percentile	43,753	35,625	41,226
Pesticides and herbicides	Mean	40,764	24,800	46,773
	Std. Dev.	19,318	21,632	27,387
	CV(%)	47.39	87.23	58.55
	Minimum	7,325	8,000	8,715
	Maximum	81,000	76,000	97,820
	75th percentile	52,545	23,872	64,165
	25th percentile	25,762	14,570	27,921
Harvest transportation	Mean	16,603	14,385	18,731
	Std. Dev.	3,373	4,405	6,987
	CV(%)	20.32	30.62	37.30
	Minimum	10,200	10,260	9,045
	Maximum	24,000	21,600	29,600
	75th percentile	17,610	17,515	23,915
	25th percentile	15,784	11,000	13,042
Machinery rent (includes land preparation and harvesting)	Mean	68,920	59,995	72,208
	Std. Dev.	13,419	21,724	21,695
	CV(%)	19.47	36.21	30.05
	Minimum	39,450	30,540	34,870
	Maximum	105,800	96,160	111,850
	75th percentile	73,959	68,346	78,800
	25th percentile	66,680	45,432	61,552
Hired labor	Mean	11,449	11,392	13,487
	Std. Dev.	9,755	10,140	10,657
	CV(%)	85.21	89.01	79.02
	Minimum	0	0	0
	Maximum	29,959	27,640	36,670
	75th percentile	18,608	17,200	18,513
	25th percentile	2,800	0	6,968

* Based on information collected from 40 households

**1¢= 1 Colon= 0.00234390 USD

Table 2.15, 2.16 and 2.17 show the results of the simple t-tests made to check if we can find statistically significant differences among farmers of Bagatzi, Falconiana and La Soga. According with the results of these tables there is no statistically significant difference in the use of hired labor among the farmers. In general, the great variability in the use of hired labor among farmers of these communities responds mainly to the high susceptibility of the seed's varieties used in this area that makes necessary sometime the application of more pesticides or herbicides than the usual quantity applied of these products.

Table 2.15. t-Test: two-sample assuming unequal variances for use of hired labor among farmers of Falconiana and La Soga

	Bagatzi	Falconiana
Mean (quintal ha^{-1})	11,448	11,392
Variance	95,161,920	102,827,038
Observations	20	9
Hypothesized Mean Difference	0	
Df	15	
t Stat	0.01	
P(T<=t) two-tail	0.98	

Table 2.16. t-Test: two-sample assuming unequal variances for use of hired labor among farmers of Falconiana and La Soga

	Bagatzi	La Soga
Mean (quintal ha^{-1})	11,448	13,487
Variance	95,161,920	113,580,696
Observations	20	12
Hypothesized Mean Difference	0	
Df	22	
t Stat	-0.54	
P(T<=t) two-tail	0.59	

Table 2.17. t-Test: two-sample assuming unequal variances for use of hired labor among farmers of Falconiana and La Soga

	Falconiana	La Soga
Mean (quintal ha^{-1})	11,392	13,487
Variance	102,827,038	113,580,696
Observations	9	12
Hypothesized Mean Difference	0	
Df	18	
t Stat	-0.45	
P(T<=t) two-tail	0.65	

For the case of farmers of San Ramon and Playitas the cost of labor is not comparable with the hired labor costs in the other communities. The application of fertilizers, pesticides and herbicides is almost 100% mechanized with the use of airplanes and tractors. Safety issues involved with the manipulation of these chemicals have changed the way used to apply these products. The direct use of hired labor is related with maintenance activities and irrigation.

2.6. Yields and revenues

Table 2.18 shows the statistics on overall total production, yields and revenues associated with the rice production in the communities included in this survey (not including farmers of San Ramon and Playitas). The high variation in total production and total revenues are partly explained for the differences in land area cultivated. Some farmers distribute their lands among several crops and the land area for rice cultivation in these cases is smaller.

Table 2.18 also shows a coefficient of variation of 30% and 35% for rice yield (quintals per hectare) and revenues per area (Colones per hectare).

Considering the rice production for farmers in the different communities included in this study, during the second rice season of 2003, the average rice yield was 106.16 quintals per hectare in Bagatzi, 101.71 quintals per hectare in Falconiana and 111.71 quintals per hectare in La Soga (Table 2.19). These average yields were not statistically significantly different at the 5% level (Tables 2.20, 2.21 and 2.22). These results are according with the no difference among farmers when considering the same use of seeds and agrochemicals, and the same production system (we could have expected same rice yields for farmers of Bagatzi, Falconiana and La Soga).

Table 2.18. Descriptive statistics on overall mean production, yields and revenues of rice production around Palo Verde, Costa Rica

		Overall Statistics[*]
Total production (Quintals[**])	Mean	1,159
	Std. Dev.	1,063
	CV(%)	91.73
	Minimum	134
	Maximum	4,756
	75th percentile	1250
	25th percentile	511
Yield (Quintals/ha)	Mean	107
	Std. Dev.	32.19
	CV(%)	30.11
	Minimum	52
	Maximum	199
	75th percentile	120
	25th percentile	84
Total Revenues (Colones[***])	Mean	4,419,816
	Std. Dev.	4,239,212
	CV(%)	95.91
	Minimum	545,619
	Maximum	19,369,262
	75th percentile	4,793,904
	25th percentile	1,940,283
Revenues per hectare (Colones/ha)	Mean	394,172
	Std. Dev.	140,772
	CV(%)	35.71
	Minimum	182,488
	Maximum	766,636
	75th percentile	469,374
	25th percentile	320,477

[*] Based on information collected from 40 households
[**]1 Quintal = 46 kilograms
[***]1¢= 1 Colon= 0.00234390 USD

Table 2.19. Average yields of rice production around Palo Verde, Costa Rica (Colones ha^{-1} at constant 2003 prices)

		Agricultural community[*]		
		Bagatzi	Falconiana	La Soga
Average rice yield (quintals[**] ha^{-1})	Mean	106.15	101.71	111.71
	Std. Dev.	21.64	32.21	46.46
	CV(%)	20.39	31.67	41.59
	Minimum	55.00	66.7	52.00
	Maximum	146.00	160	199.00
	75th percentile	117.87	113	130.00
	25th percentile	96.77	82.25	76.75

[*]Based on information collected from 40 households
[**]1 quintal= 45 kilograms

Table 2.20. t-Test: two-sample assuming unequal variances for rice yield among farmers of Bagatzi and Falconiana

	Bagatzi	Falconiana
Mean	106.15	101.7125
Variance	468.56	1,037.48
Observations	20	8
Hypothesized Mean Difference	0	
df	10	
t Stat	0.35	
P(T<=t) two-tail	0.72	

Table 2.21. t-Test: two-sample assuming unequal variances for rice yield among farmers of Bagatzi and La Soga

	Bagatzi	La Soga
Mean	106.15	111.71
Variance	468.56	2,159.00
Observations	20	12
Hypothesized Mean Difference	0	
df	14	
t Stat	-0.39	
P(T<=t) two-tail	0.70	

Table 2.22. t-Test: two-sample assuming unequal variances for rice yield among farmers of Falconiana and La Soga

	Falconiana	La Soga
Mean	101.71	111.71
Variance	1,037.48	2,159.00
Observations	8	12
Hypothesized Mean Difference	0	
df	18	
t Stat	-0.56	
P(T<=t) two-tail	0.57	

2.7. Rice returns and profitability

2.7.1. *Profits: returns to material inputs*

Production of rice in this region involves the use of several material inputs. These material costs included seeds, fertilizers, pesticides and herbicides, harvest transportation, and machinery rent because these costs are considered the main material costs involved in rice cultivation. Considering only the material costs and the revenues that farmers get from the rice production in the communities included in this survey, Table 2.23 shows the overall descriptive statistics of the rice returns.

Table 2.23. Descriptive statistics on overall net returns associated to the rice production around Palo Verde, Costa Rica (Colones ha^{-1} at constant 2003 prices)

		Overall Statistics*
Net returns (Colones**/ha)	Mean	190,431
	Std. Dev.	113,882
	CV(%)	59.80
	Minimum	-55,062
	Maximum	507,637
	75th percentile	254,274
	25th percentile	121,750

* Based on information collected from 40 households
** 1 Colon= 0.00234390 USD

Now considering only the material cost and the gross returns for selling the rice production, the average returns for farmers of Bagatzi was ¢175,804 ha^{-1}, ¢200,196 ha^{-1} for farmers of Falconiana and ¢208,300 ha^{-1} for farmers of La Soga (Table 2.24). No statistically significantly differences were found using a t-test (Tables 2.25, 2.26 and 2.27).

Table 2.24. Returns of rice production (Colones ha^{-1} at constant 2003 prices)

		Agricultural community*		
		Bagatzi	Falconiana	La Soga
Rice production returns (Colones*/ha)	Mean	175,804	200,196	208,300
	Std. Dev.	82,119	114,785	158,563
	CV(%)	46.71	57.34	76.12
	Minimum	9,040	66,205	-55,062
	Maximum	304,144	437,065	507,637
	75th percentile	246,440	238,876	292,566
	25th percentile	130,252	131,550	112,932

* Based on information collected from 40 households
** 1 Colon= 0.00234390 USD

Table 2.25. t-Test: two-sample assuming unequal variances for rice production returns among farmers of Bagatzi and Falconiana

	Bagatzi	Falconiana
Mean	175,804	200,196
Variance	6,743,591,534	13,175,615,940
Observations	20	8
Hypothesized Mean Difference	0	
df	10	
t Stat	-0.54	
P(T<=t) two-tail	0.59	

Table 2.26. t-Test: two-sample assuming unequal variances for rice production returns among farmers of Bagatzi and La Soga

	Bagatzi	La Soga
Mean	175,804	208,300
Variance	6,743,591,534	25,142,403,317
Observations	20	12
Hypothesized Mean Difference	0	
df	15	
t Stat	-0.65	
P(T<=t) two-tail	0.51	

Table 2.27. t-Test: two-sample assuming unequal variances for rice production returns among farmers of Falconiana and La Soga

	Falconiana	La Soga
Mean	200,196	208,300
Variance	13,175,615,940	25,142,403,317
Observations	8	12
Hypothesized Mean Difference	0	
df	18	
t Stat	-0.13	
P(T<=t) two-tail	0.89	

To test differences in rice production returns, a z-test was used to compare the average returns of farmers of San Ramon and Playitas. For the case of farmers of these two communities, the average rice yield production was 102.12 quintals ha^{-1} and the average rice production return was 253,723 Colones ha^{-1} (this net return is considering gross returns for selling the rice production less the material costs only). The results of the z-test are shown on Table 2.28.

Table 2.28. Significance test for population mean use of seeds and fertilizers

	Bagatzi, Falconiana and La Soga	
	Rice production yield (quintals ha^{-1})	Average returns (Colones ha^{-1})
Number of cases	40	40
Mean	107	190,431
SD	32.19	113,882
P-value	0.34*	0.00**

*It provides no evidence to reject the hypothesis (H_o=102.12 quintals ha^{-1})
** It provides strong evidence to reject the hypothesis (H_o=¢253,723 ha^{-1})

Given the similar rice production yield, the results of Table 2.28 related with the statistically significant difference between San Ramon and Playitas, and the other three communities are not surprising. Regarding the average returns, we have to consider that for the case of farmers in San Ramon and Playitas, they have an agreement with a private company to sell their rice production. This company ensures a price that is attractive to the farmers and everybody receive the same price.

Labor costs were not included on this analysis. On this point, we could expect more differences especially with San Ramon and Playitas given their more mechanized production system which demands less labor. Another consideration on these results is the fact that we did not include any fixed cost (mainly irrigation, land taxes and interest payments).

An important point to consider when interpreting these results is the fact that we are estimating gross returns based on the 2003 rice price that farmers received for their production. This is very important because imported rice in Costa Rica must pay a tariff that elevates its price affecting the domestic price that farmers receive for their production. This is a topic that is going to be analyzed on the third chapter of this study.

2.7.2. *Profits: returns to household land and labor*

To calculate the profitability of the rice production, data were collected on inputs use (variable and fixed inputs), yields (rice productivity per hectare), input and output prices. Table 2.29 shows the different cost categories included in this survey and that were collected in the field during the summer of 2003 by the author.

Table 2.29. Variable and fixed inputs included in the estimation of rice profitability

Variable rice production costs
Seeds
Fertilizers
Herbicides, fungicides and insecticides
Transportation
Agricultural machinery
Labor
Fixed rice production costs
Irrigation
Technical assistance
Crop insurance
Financial cost

The costs presented in Table 2.29 are the main costs involved in the rice production in Costa Rica according with the Costa Rican Rice Office. These costs were estimated for every farmer included in this survey and were collected using a structured interview. Table 2.30 shows the results of the data collection on rice production costs considering the costs presented in Table 2.31.

Table 2.30. Rice production costs (Colones ha^{-1} at constant 2003 prices)

Variable rice production costs*	**Mean cost (Colones**/ha)**	**Standard deviation**	**Coefficient of variation (%)**
Seeds	38,904	4,300	11.05
Fertilizers	50,396	14,864	24.49
Herbicides, fungicides and insecticides	39,374	23,211	58.95
Transportation	16,798	5,016	29.86
Agricultural machinery	68,122	18,006	26.43
Labor***	38,926	17,636	45.31
Fixed rice production costs			
Irrigation	8,959	1,017	11.35
Technical assistance	2,244	2,487	110.87
Crop insurance	8,911	6,319	70.92
Financial cost	162,566	147,391	90.7

*Based on information collected from 40 households
**1 Colon= 0.00234390 USD
***Included only hired labor

According with the Table 2.18, the mean revenue per hectare was 394,172 Colones with a coefficient of variation of 35.71% considering all the farmers including in this survey. Table 2.31 shows the descriptive statistics for total profits, that is all cash rice income minus all cash outflows according with Table 2.30.

Table 2.31. Total profits of rice production (Colones at constant 2003 prices)

		Overall Statistics*
Total profits (Colones**)	Mean	1,532,140
	Std. Dev.	1,872,099
	CV(%)	122.18
	Minimum	-739,722
	Maximum	9,481,955
	75th percentile	2,109,847
	25th percentile	497,071
Profits per area (Colones/ha)	Mean	140,596
	Std. Dev.	117,741
	CV(%)	83.74
	Minimum	-108,782
	Maximum	485,389
	75th percentile	207,031
	25th percentile	72,940

*Based on information collected from 40 households
**1 Colon= 0.00234390 USD

The Table 2.31 is the result of the data collection on three agricultural communities located around Palo Verde and about rice production. This table presents profits farmers obtained from the rice cultivation only during the rainy season of 2003. High variability in the total profits is the results of the current system used to produce the rice associated with high chemical costs and use of seeds varieties highly susceptible to pests. The use of financial loans and technical assistance provides additional variation compared with farmers that cultivate the land with their own financial resources.

The estimation of Table 2.31 is based on gathered information on different inputs and output price. These prices were collected during the field interviewing process where every farmer responded about the prices that they pay for seeds, fertilizers and hired labor. The farmers also were asked about the price they receive for their rice production. No input prices were collected for pesticides and herbicides mainly due to the great variability in product used and the difficulty of farmers to remember the different prices they pay for every single product.

According with the Table 2.31 only 25% of the farmers got a total profit less than 497,000 Colones. If we consider that the rice season lasts five months, these farmers are getting a monthly salary of approximately 100,000 Colones (234 USD per month approximately). For the other side, only 75% of the farmers got a profit greater than 2,109,000, in this case these farmers are getting a monthly salary of approximately 422,000 Colones (almost 1,000 USD per month).

2.8. Conclusions

The present chapter aimed to describe the current situation associated with the rice production in five agricultural communities located around Palo Verde, Costa Rica. In specific, it presented a summary of whether and in which cases there is significant variation across communities, difficulties with data collection, and the environmental impacts/implications of different production systems and input use.

Information on the study area, land characteristics, land tenure, input and outputs was included with the main purpose of determining the overall profitability of the rice production, the variables that most influence the level of profits and the differences that exist among farmers of the different communities included in this survey.

Regarding the methodology used to collect the data in the field, the main problem was associated with the difficulty to recover information about input prices. The high diversity of inputs used, especially agrochemicals, makes difficult for the farmers to remember all the details. In general, the farmers interviewed do not keep records of their expenses and activities.

We could not find big differences in the production system used to produce the rice. Only farmers in San Ramon and Playitas show differences with the rest. In this case, the intensive use of machinery and the methods used to plant the seeds and prepare the land appear as the main differences.

The *fangueo* appear to be the most common mechanized method to prepare the land on a wet condition, but only farmers of Bagatzi, Falconiana and La Soga use this land preparation technique. Information collected about this technique suggests that this activity could be associated with a high level of soil erosion and of agricultural runoffs. This conclusion has been highlighted in previous studies about the environmental impacts of the agricultural runoff on wetlands of Palo Verde. Given the intensive use of fertilizers in this region, the wetland contamination may be highly associated with fertilizer consumption. This issue will be considered in the rest of this study

Farmers of San Ramon and Playitas don not practice the *fangueo*, suggesting that a lower level of soil erosion could be associated with this group of farmers. This information could help to compare groups according with the environmental impact rice cultivation causes on the wetlands of Palo Verde.

In relation with input use, output production and revenues we did not find statistically significant differences among farmers of Bagatzi, Falconiana and La Soga. San Ramon and Playitas presented differences in the use of seeds and fertilizers. For the average returns, we also found differences; in this case farmers of these two communities in average are getting a higher level of return. The fixed costs included to determine the level of profitability are irrigation, crop insurance, technical assistance and financial cost.

In average farmers of Bagatzi, Falconiana and La Soga are getting a level of profits of approximately 1,530,000 Colones. However there is an important variation in the level of profits that farmers are getting from the rice production. It is believed that this high variation is partly due to the intensive and varied used of pesticides and herbicides (variation given by the high susceptibility of the rice seed to pests), the high interest rate that some farmers have to pay for financial loans, and the more or less intensive use of hired labor.

There are also opportunity costs for using household labor and land for rice production that this study is not representing here. This could add an even higher level of variation in the final level of profitability.

3. Econometric analysis of profitability associated with rice production around Palo Verde, Costa Rica

3.1 Introduction

Most of the Guanacaste Province is rural and many people in the area make a living from agriculture. The small landowners generally earn low profits due to factors like low productivity, obsolete technology, difficulties commercializing output, and high input prices.

The National Production Council of Costa Rica identifies the limited diversification, the lack of and sometimes inefficient technical assistance, farmers resistance to changes, short-term policies, irrational use of the hydrological resources and low profitability as the major causes of the small aggregate value of the agricultural production in the Chorotega Region, which includes the Guanacaste Province in Costa Rica (Costa Rican Rice Office, 2001).

The Arenal-Tempisque Irrigation Project, conceived between 1975 and 1978, is located in the Guanacaste Province. Currently irrigates about 20,000 hectares of agricultural land, which is mainly planted to rice and sugar cane. The water district maximizes profits from agricultural production. The profit from farming is the total revenue from rice farming minus the variable costs and the fixed costs of farming. However, farmers around Palo Verde are worried about the variability of the markets price, increasing of rice imports and high input cost (Perez, 2001).

Given the information collected in the field and the estimation of profits for every farmer included in this study, this chapter presents an econometric analysis of rice profitability to identify the variables that most affect the level of profits obtained. This paper examines the level of profits recognizing that input and output prices, fixed factors, and soil conditions may vary among farms and communities.

This analysis can help inform the design of new programs to increase the profitability of rice production given the existing technology or to promote changes in technology, to provide more active technical assistance, or even to consider land conversion to more attractive alternatives.

3.1.1. *Tariff Application on imported rice in Costa Rica*

One of the factors that is believed most affect the level of profitability associated with the domestic production of rice in Costa Rica is the tariff applied on imported rice. This program mandates a payment of a tariff when importing rice to protect local producers. This tariff elevates the domestic rice price and help to farmers to increase their incomes and reduce the incidence of poverty especially among small landowners.

In the last six years, Costa Rica has improved access to its already generally open market, particularly for goods. It has reduced the average tariff to 7 percent and has adopted an export-oriented strategy based on tariffs and other fiscal concessions. This strategy has contributed to rapid but variable economic growth, according to a World Trade Organization (WTO) report on the trade policies and practices of Costa Rica released in 2001. However, Costa Rica maintains various import restrictions and prohibitions, generally for health, security or environmental reasons. Among these restrictions, safeguard measures are applied to rice and beans under the WTO Agreement on Agriculture. Specifically, a price-support program for Costa Rican paddy farmers was introduced in 1990. Currently Costa Rica applies a tariff of 35% to imported rice.

Figure 3.1 depicts the difference between the price of the imported rice and the world price of rice attributed to the tariff application. Because of the tariff, foreign production is sold with a higher price in the local market to compensate the cost of the tariff for introducing the imported production into the country. Higher price of imported rice leads to a higher domestic price. Price trend was estimated on data of the Costa Rican Rice Office, FAO and the International Rice Research Institute (IRRI).

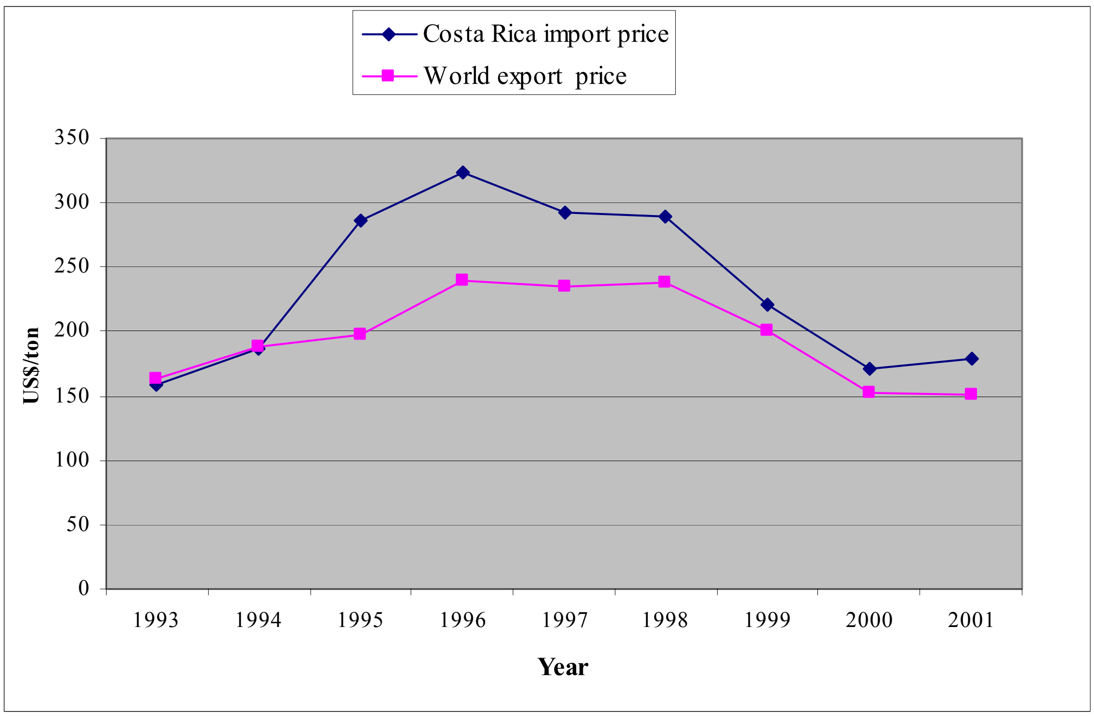

Figure 3.1. Costa Rican tariff impact on imported rice price (Source: Rice Office, FAO and IRRI)

The sustained difference between domestic and international rice price has promoted the development of an intensive rice production around the country, especially within the Chorotega Region that includes the Guanacaste Province. However, no previous studies have been developed to explain the variables that drive the level of profitability associated with the rice production around Palo Verde, and the impact of the current tariffs on the level of profits that farmers can earn.

3.1.2. *Rice Productivity at the national level*

The Costa Rican Rice Office annually generates national statistics associated with rice production. These statistics include production, commercialization, imports, exports and historical data to have a complete description of the rice business in the country.

Based on the pluviometric regime, five zones of rice production were established by the Costa Rican Rice Office. These zones were defined because they are the only zones in the country with adequate infrastructure, transport access and storage capabilities. During the period 2000/2001, 66,083 hectares were planted (Table 3.1). The Chorotega Region was the main producer region representing 45.96% of the total national rice production (Costa Rican Rice Office, 2001). During this period, the national rice yield was 4.16 metric tons per hectare. Figure 3.2 shows the trends in terms of productivity per area planted and total area cultivated. Between 1999 and 2001, the area planted decreased by only 0.02% whereas the productivity per hectare decreased by 14.07%.

In Costa Rica 64% of the rice production receives irrigation. For the Chorotega Region, during the period 2000-2001 23,465 hectares (35%) were cultivated with irrigation. This represents an increase of almost 30% compared with the area planted with irrigation during 1992-1993. In spite of the improvements in cultivation techniques adopted by Costa Rican farmers in the last ten years, between 1999-2001 Table 3.1 shows a decrease in total production and productivity. Among the factors that could explain it are the smaller number of producers (4,000 during 1983-84 and 1,566 during 1999-2000) caused by lack of sources of funding, the arbitrary rice price establishment and the lack of technical assistance and research (Sanabria, 2000 cited by Perez, 2002).

Table 3.1. Area cultivated and rice yield in Costa Rica

Year	Area (ha)	Total Production (metric tons/ha)	Metric tons per hectare
1980/81	84,629	243,590	2.88
1981/82	72,294	202,037	2.79
1982/83	76,599	148,372	1.94
1983/84	88,351	281,388	3.18
1984/85	72,335	222,740	3.08
1985/86	73,949	249,392	3.37
1986/87	55,741	180,635	3.24
1987/88	40,132	149,800	3.73
1988/89	43,245	172,001	3.98
1989/90	63,398	245,284	3.87
1990/91	51,930	217,428	4.19
1991/92	48,166	210,257	4.36
1992/93	52,481	210,657	4.01
1993/94	42,861	177,938	4.15
1994/95	44,112	194,254	4.40
1995/96	39,179	196,307	5.01
1996/97	58,395	242,438	4.15
1997/98	59,333	242,359	4.08
1998/99	56,185	263,491	4.69
1999/2000	66,096	319,565	4.83
2000/2001	66,083	274,595	4.16

Source: Costa Rican Rice Office (2001)

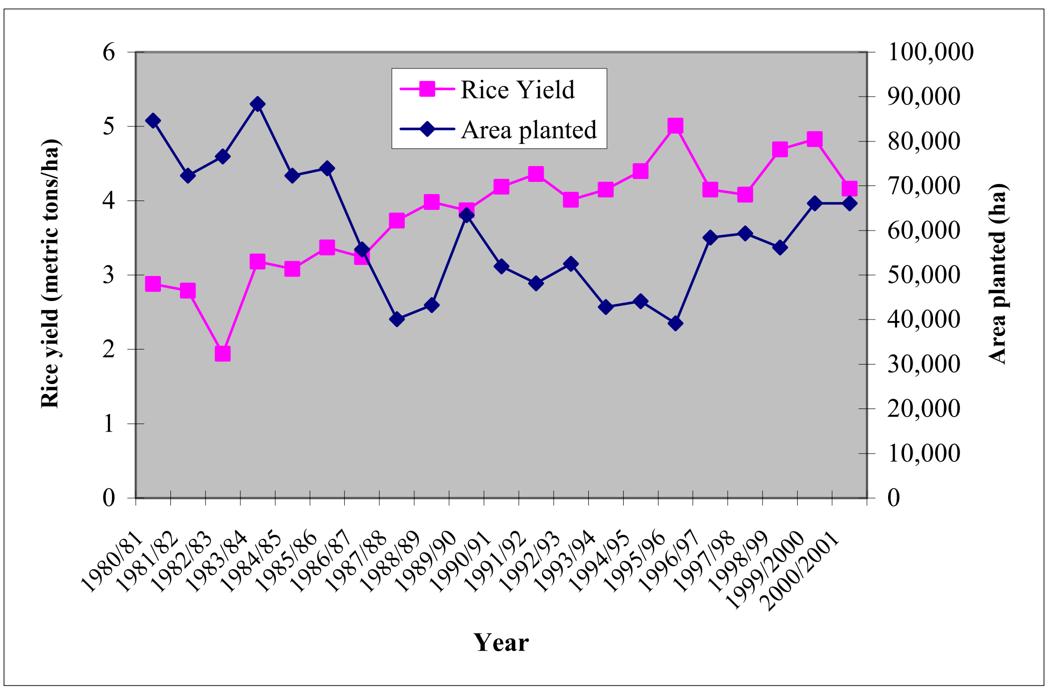

Figure 3.2. Rice productivity and area planted in Costa Rica

3.1.3. *Rice profitability at the national level*

The Costa Rican Rice Office tracks the costs of labor, machinery, material inputs, administration, financing and marketing, as the main costs of rice production in Costa Rica. In January 2001, the total production cost was 370,899 Colones per hectare, 10.73% higher than the cost for January 2000 in nominal terms and 1% higher in real terms (Rice Office, 2001).

Taking into consideration the production costs between 1991 and 2001, the total production, and the nominal domestic price of rice, Table 3.2 shows the total profits obtained (in nominal values). The negative profits in 2001 are due mainly to a reduction in productivity and an increase in the costs of production.

Table 3.2. Total profits of rice production in Costa Rica (nominal values)

Year	Total revenues (Colones/ha)	Total costs (Colones/ha)	Total profits (Colones/ha)	Total profits* (USD/ha)
1991	154,439	131,079	23,360	172
1993	155,439	142,527	12,912	86
1994	180,568	160,146	20,422	124
1995	221,371	185,402	35,969	199
1996	291,723	214,100	77,623	373
1997	287,691	255,792	31,899	137
1998	305,694	281,528	24,166	94
1999	375,183	301,288	73,895	258
2000	409,906	334,958	74,948	243
2001	352,310	370,899	-18,589	-56

* Profits in dollars at given years' exchange rate
Source: calculations based on Costa Rican Rice Office statistics on rice production and costs

In Chapter 2, a total profit of 140,596 Colones per hectare was estimated for the households included in this study. These results can be influenced for the good agronomic conditions of the study area to cultivate rice and the intensive use of fertilizers. The estimated total costs for the farms included in this study was 435,200 Colones per hectare and can be explained for the intensive use of agrochemicals (fertilizers, pesticides and herbicides).

3.2. Conceptual model

3.2.1. *The normalized restricted profit function model*

The empirical analysis was based on the profit function approach. Specifically, the farm household was assumed to maximize “restricted profits”, defined as the gross value of output less out of pocket variable costs, subject to a given technology and given quantities of fixed factors and conditional on quasi-fixed joint costs.

The resultant profit function depicts the maximum profit attainable for given input and output prices, fixed factors, and production technology. For a single output (i.e. rice), it is convenient to specify a normalized profit function, defined as the ratio of profits to the output price, as a function of the prices of inputs relative to output price and fixed factors (Farooq, et al. 2001).

To analyze rice production around Palo Verde, we assume that the production function is given by

$$\begin{aligned} Y &= F(X,Z) \\ &= F(X_1,\ldots,X_m;Z_1,\ldots,Z_n) \qquad (1) \end{aligned}$$

where Y is the rice output, and X and Z are the vectors of variable and fixed inputs, respectively.

In essence, the duality theory of production states that under certain regularity conditions, the profit function (for that matter, cost function) contains the same information as the production function about the underlying production technology (Ahammad and Islam, 1999).

Determination of the true functional form of a given relationship is impossible. This problem leads to consideration of choice criteria, that is, how one functional form may be judged better than another. These criteria may be grouped in four categories according to whether they relate to maintained hypotheses, estimation, data, or application (Griffin, R. et al. 1987). For the case of this study, several functional forms were tested empirically, and based on the coefficient of correlation of each model and the number of significant variables, the functional form was selected.

Using the duality theory as proposed by Lau (1976), a normalized restricted profit function can be derived as

$$\Pi = \Pi(W_1,\ldots,W_m;Z_1,\ldots,Z_n) \qquad (2)$$

where Π is the restricted profit and W and Z are the vector of variable input prices and fixed inputs respectively . Both Π and W are normalized (divided) by the price of output (rice), P_y.

The profit function gives the maximized value of the profit for each set of values $\{P_y; W_1,\ldots,W_m; Z_1,\ldots,Z_n\}$(Lau and Yotopoulos, 1971).

The normalized restricted profit is the maximum profit given by

$$\Pi(W,Z) = F(X^*,Z) - \sum_{i=1}^{m} W_i X_i^* \qquad (3)$$

where X^* indicates the quantity of X which maximizes the normalized profit given Z.

The parameters of the profit function will be estimated by single equation Ordinary Least Squares (OLS) procedure.

3.2.2. *Evaluation of rice profitability and policy implications*

The estimation of the profit function from the previous section will permit to identify the significant variables that determine the level of profits farmers can earn in this region. Based on these significant variables, estimation of new OLS regression analysis will be developed to determine a new profit function using only the statistically significant variables. With these new functions, the profitability of rice production around Palo Verde will be analyzed under conditions of risk and uncertainty. The effect of risk on profitability was evaluated through Monte Carlo simulation.

Results of the risk analysis are intended to provide the farm manager-decision maker with a compendium of possible outcomes that could be obtained under different scenarios (Valderrama and Engle, 2000). The scenarios are modeled according to the characteristics of the rice production around Palo Verde given the results of the estimated profit function, and including the price differences that the tariff application on imported rice in Costa Rica create between the domestic price and the international price. This analysis will permit us to evaluate the impact of the tariff application on imported rice in Costa Rica.

The risk analysis will be conducted as a stochastic simulation using Crystal Ball™ software. This is a spreadsheet add-in program that allows the incorporation of uncertainty in risk analysis model. In the simulations, ranges of values that individual variables or parameters may take are defined by probability distributions instead of the single mean values used in standard enterprise budgets. Monte Carlo simulation techniques (using 1,000 iterations) are used to generate values for individual cost and quantity parameters based on the probability distribution. Results present the entire range of possible outcomes and the likelihood of achieving them (Valderrama and Engle, 2000).

3.3. Data Sources

The data used for this analysis were collected during the summer of 2003 (June-July) by the author. Production data from 40 farmers in the communities of Bagatzi, Falconiana and La Soga are included. The variables required to estimate normalized profits (dependent variable) are input prices (seeds and fertilizer), and fixed inputs. Fixed inputs included capital input (index of capital intensity and could also be interpreted as technology), irrigation cost (index of financial management skills), and family size. Table 3.3 shows the descriptive statistics of the variables included in this analysis. The coefficients of variation suggest that there was enough variation across farmers to permit statistically significant parameters to be estimated. The susceptibility of rice seeds to pests explained the variability in the cost of agrochemicals; minor differences in management among farmers can cause big differences related to the presence of pathogens that affect the crop.

Table 3.3. Descriptive statistics of variables included in the profit analysis

Variable	Description	Mean***	Standard deviation	Coefficient of variation (%)
Π	Profit	178,670	113,477	63.51
W_1	Price of rice seeds (Colones*/quintal**)	9,769	861	8.81
W_2	Price of Fertilizers (Colones/quintal)	4,864	1,253	25.78
Z_1	Index of capital intensity (sum of costs of insecticides, fungicides, herbicides, transportation and machinery) (Colones/ha)	124,295	33,299	26.79
Z_2	Cost of irrigation (Colones/ha*semester)	8,959	1,017	11.35
Z_3	Family size (number of people)	4.7	2.1	46.34
D_c	Community dummy variable = 1 if farmer cultivates in Falconiana and zero otherwise	0.20	0.40	---

* 1 USD = 427 Colones
** 1 quintal = 46 kilograms
*** Including 40 households of Bagatzi, Falconiana and La Soga

Irrigation cost is treated as a proxy for financial management skills because farmers pay interest when they do not pay for the irrigation bill on the due date every semester (two payments a year). Given this definition we could expect a positive impact of this variable on profits farmers can earn. For the case of family size a positive impact on profits is expected.

In the second chapter, no statistically significant differences were found among farmers of Bagatzi, Falconiana and La Soga (the three communities included in this analysis) on the variables shown in Table 3.3. However, a dummy variable for farmers of Falconiana was included to test for differences in fertilizer use. Personal communications with several specialists in this area suggested that Falconiana is characterized by higher soil quality. The index of capital intensity was included to test the impact of the intensive use of agrochemicals (especially pesticides and herbicides) on the level of profits farmers can earn.

For the risk analysis, secondary data were used. Information was collected from different sources (Costa Rican Rice Office, FAO and IRRI) about international and domestic rice price in Costa Rica. Figure 3.3 shows the evolution of domestic and international price and their differences. The Costa Rican Government currently applies a 35% tariff on imported rice, keeping with these a fairly constant evolution in nominal terms compared with the clear decreasing tendency of the international price. In this case (as opposed in Figure 3.3) the international price shows the world trend without the influence of the tariff.

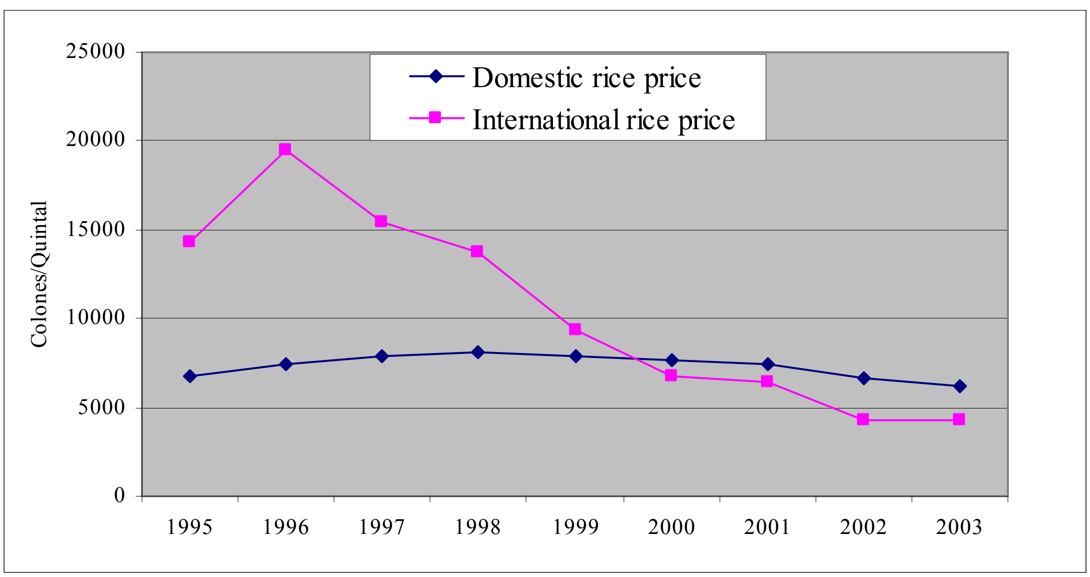

Figure 3.3. Domestic and international rice price in Costa Rica (Source: Costa Rican Rice Office, FAO and IRRI)

3.4. Empirical Results

3.4.1. Normalized profit function

Following Adesina and Djato (1996), the profit function is specified as Cobb-Douglas:

$$\ln\Pi^* = \ln A^* + \delta_c^* D_c + \sum_{i=1}^{2} \alpha_i^* \ln W_i + \sum_{i=1}^{3} \beta_i \ln Z_i \qquad (8)$$

where Π^* is the normalized profit in Colones per hectare (427 Colones = 1USD in 2003), defined as revenue less out of pocket variable costs (seeds, fertilizers, pesticides, transportation, machinery and hired labor) normalized by the price of rice P_y; A^* is the intercept; D_c is a dummy variable taking the value of one for farmers located in Falconiana; W_1 is the price of rice seeds normalized by the price of output; W_2 is the price of fertilizer normalized by the price of output; Z_1 is the index of capital intensity and is the sum of costs of insecticides, fungicides, herbicides, transportation and machinery; Z_2 is the irrigation payment; and Z_3 is family size.

Given the functional form specified in (8), we should expect a positive signs associated with the dummy variables (better soil quality should lead to a better productivity and therefore higher profits). Whereas for the case of capital intensity we should also expect a positive sign. For the case of input prices (fertilizer and seeds) we should get a negative sign.

For the estimation of the profit function, the natural logarithm of negative profits were treated as one.

According with the functional for presented in (8), the parameter estimates of the profit function are reported in Table 3.4.

Table 3.4. Estimation of the normalized profit function for rice production around Palo Verde, Costa Rica

Independent variables	Parameter	Estimated coefficient (OLS)	Standard error	P-value
Profit function constant	ln A	1.762	9.839	0.858
W_1 Seed price	α_1	-2.375^{++}	0.951	0.017
W_2 Fertilizer price	α_2	-0.737	0.661	0.272
Z_1 Capital intensity	β_1	0.744^{+}	0.457	0.112
Z_2 Irrigation cost	β_2	-0.755	1.083	0.490
Z_3 Family size	β_3	-0.002	0.227	0.989
D_c Community dummy	δ_c	0.451	0.344	0.199
N	40			
R^2	0.308			
Adjusted R^2	0.182			
F-value	2.45			0.045

$^{+}$ statistically significant at the 15% level
$^{++}$ statistically significant at the 5% level

The estimated coefficients of the normalized variable input prices are negative, as expected from theory of profit maximization, but only the price of seeds is statistically significant at 5% level. This implies that an increase in the normalized price of seeds reduces the normalized profit. The parameter estimates on the index of capital intensity (quasi-fixed input on technology) is positive and significant at the 15% level. The estimated coefficients on irrigation payment and family size are not statistically different from zero and therefore nothing can be concluded on the impact of these variables on profits. This insignificance may due to lack of sufficient sample size, lack of variation among farmers, and also because family size is a poor measure of labor availability for farming. Some family members may work outside the local area. Some may be highly skilled and experienced at farming. This detailed information on human capital was not collected during the interviews in the field.

The coefficient on the community dummy is significant but only at the 20% level. Given the small sample size, this result at least suggests that farmers in Falconiana make higher profits than farmers in the other two communities included in this survey. Falconiana is recognized for having more diversified crop production, including watermelons, melons, tomatoes, onions and other minor crops. This higher diversification is attributed to better soil quality. In fact the dummy could be treated as an index of soil quality (fixed input involved in rice production)

Future research should collect measures of physical production factors (e.g. soil fertility) to explain differences in profits among farmers. This information could contribute to the design of customized policies or regulations considering biophysical conditions that affect the level of agricultural productivity.

The estimation results also confirm the impact that the intensive use of agrochemicals (especially pesticides and herbicides) is having on final profits, as capital intensity is positive and significant at the 15% level. Current seed varieties used in this region of Costa Rica are highly sensitive to management practices and susceptible to disease. This may explain why high capital intensity leads to higher profits. This suggests that one way to reduce environmental impacts of rice farming would be to introduce new seed varieties that are more resistant and therefore less demanding of agrochemicals.

Alternative specifications of profit function including additional fixed factors were tested, but no statistically significant effects were identified. These alternatives included farm area, a dummy for technical assistance, hours of family labor, and cost of hired labor.

In general, the estimated profit function was significant at the 5% level (F-value and probability). However, the model could explain only 30.8% of the variation in profits among farmers. More data are needed; the inclusion of other communities around Palo Verde or repeated observations on the sample farmers across years could help explain the variation of profits.

3.4.2. Rice profitability and policy analysis

The estimates of the profit function presented in the previous section determined that only capital intensity and seed price were significant at the 5% and 15% level respectively. Using these results a new OLS regression analysis was developed to determine a new profit function using only the statistically significant variables. With this new function, the profitability of rice production around Palo Verde was analyzed under conditions of risk and uncertainty. Table 3.5 shows the new estimates for the profit function.

Table 3.5. New estimates of the normalized profit function for rice production around Palo Verde, Costa Rica. Only significant variables determined in previous section were included.

Independent variables	Parameter	Estimated coefficient (OLS)	Standard error	P-value
Intercept	$\ln A^*$	-1.174	4.512	0.796
W_1 Seed price	α_1^*	-2.635^+	0.796	0.002
Z_1 Capital intensity	β_1	0.445	0.389	0.259
N	40			
R^2	0.234			
Adjusted R^2	0.192			
F-value	5.66			0.007

$^+$statistically significant at the 1% level

The results of table 3.5 were used in Crystal Ball to simulate future profits under the two scenarios that consider domestic and international price of rice. Future variations in price of domestic rice and price of imported rice were estimated based on secondary data on prices obtained from the Costa Rican Rice Office, FAO and International Rice Research Institute (IRRI). The estimation of future prices considered the use of OLS regression analysis using as dependent variable the price and the year as the independent. The empirical specification of the price functions are given as

$$\ln DP^{1} = \alpha \ln C1 + \beta \ln Year \quad (4)$$

$$\ln IP^{2} = \gamma \ln C2 + \delta \ln Year \quad (5)$$

where DP is the price of the domestic production of rice in Colones per quintals of 160 pounds, IP is the international price of rice in Colones per quintals of 160 pounds, and C1 and C2 are the intercepts.

With the results of (4) and (5), the percentage change in domestic and international price of rice were determined based on the relationship given by

$$\% \text{ change in domestic price of rice} = (e\beta-1)*100 \quad (6)$$

$$\% \text{ change in international price of rice} = (e\delta-1)*100 \quad (7)$$

Results of (6) and (7) were used in Crystal Ball™ together with the results of the new OLS estimations to simulate future profits under two scenarios: one considering the domestic price of rice and the other considering the international price of rice.

The likelihood of achieving profits and its distribution were calculated using the estimated profit function.

For the case of the profit function, the analysis of the results, considering the domestic and international price of rice, can measure the impacts of the imported rice tariff on the level of profitability associated to rice production in the agricultural communities located around Palo Verde. The analysis of the simulation outcomes will show the future situation a typical farmer of this region could face under a free trade scenario. The same analysis can be applied

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[1] lnDP = -98.820 + 0.053 Year ($R^2 = 0.593$)
[2] lnIP = 406.349 – 0.198 Year ($R^2 = 0.904$)

to determine the probability of earning positive profits cultivating rice around Palo Verde, Guanacaste Province, Costa Rica.

Given that Crystal Ball uses probability distributions for the variables included in a risk analysis, the fit distribution menu was used to fit the best probability distribution that represent the data included. The fit distribution used the field data collected during the interviewing period and the secondary data on rice prices.

Table 3.6 summarizes the choice of probability distributions and the correspondent values selected as distribution parameters. Table 3.6 also shows the assumptions used for the international price to analyze different price scenarios. The probability distribution for capital input and rice production was based on the data collected during the field interviews in Bagatzi, Falconiana and La Soga developed during the summer of 2003 by the author.

Table 3.6. Assumptions used for the risk analysis of rice production around Palo Verde

	Profit Function			
Variable	Unit	Distribution	Parameter	Value
Rice production	Quintals160*/ha	Normal	Minimum	29.2
			Maximum	111.9
% change domestic price of rice	%/100	Normal	Minimum	0.03
			Maximum	0.08
% change international price of rice	%/100	Normal	Minimum	-0.14
			Maximum	-0.26
Seed price parameter (α_1*)	Number	Normal	Minimum	0.45
			Maximum	3.39
Capital intensity	Colones**/ha	Lognormal	Minimum	49,840
			Maximum	191,970

* 1 Quintal160 = 73.6 kilograms
** 1 USD 2003 = 427 Colones

Correlations between variables need to be defined before running the simulations for the risk analysis. Crystal Ball™ normally calculates values independently of other values. Therefore, results could be biased if existing dependencies between variables are not accounted for. International price of rice was found to be moderately correlated with domestic price of rice (r=0.43) according with the data that Figure 3.3 shows.

Table 3.7 summarizes the results of the 5-year period simulation. The entire range of possible profits level (Range minimum – Range Maximum) is given for each 5-year period considering two scenarios. The first one uses the domestic price of rice and its evolution in a 5-year period and the second one uses the international price of rice and its evolution in a 5-year period. The two scenarios give the total profits per hectare a farmer would receive facing the domestic price and the international price of rice when selling his production. Certainty levels indicate the likelihood of achieving values within a specific range.

The results of Table 3.7 also are a result of the estimation of the % changes in domestic price of rice and international price which are in average 5.54 and -18.2 respectively and associated with a probability distribution according with Table 3.5.

Table 3.7. Forecast parameter and statistics generated from Monte Carlo simulation (1,000 iterations) of profits of rice production around Palo Verde, Costa Rica

Forecast	Unit	Parameter	Price rice scenario	
			Domestic rice price	International rice price
Profits (5-yr period)	Colones*/ha	Mean	1,312,173	134,956
		Median	1,237,203	95,280
		St Dev	385,221	119,576
		CV (%)	29.36	88.60
		Range minimum	563,719	17,945
		Range maximum	2,595,476	776,225
		Certainty level	100%	9.20%
		Certainty range	270,000** to ∞	270,000 to ∞

* 1 USD 2003 = 427 Colones

** Minimum salary according with the National Institute of Statistics of Costa Rica

Table 3.7 shows a higher variation in profits farmer would earn under the scenario with the international price of rice. In this scenario farmers have to face the international price when selling their production (this scenario assumes no application of tariffs on imported rice). Under this scenario there is only a 2.9% probability of getting a profit per hectare greater than the minimum profit level a farmer would earn under the other scenario which use the domestic price of rice (in this case 563,719 Colones). These results provide evidence of the important differences of profitability considering both scenarios.

If we consider the results of Table 3.7 as the salary per hectare farmers earn during the cultivation of rice, these numbers show the descriptive statistics associated with salary level during a 5 year-period simulation. Given that we are assuming that farmers are harvesting only once every year, the annual profits of Table 3.7 have to be distributed only during 6 months every year. The other six months are covered with the profits farmers earn during the second harvesting of the year, which is a common practice for farmers in this region thanks to the irrigation.

If we also consider the results of the last household census released by the National Institute of Statistics of Costa Rica in November 2003, the average salary for the first quintile of income per household was 60,000 Colones per month. Considering this minimum salary, a household in this quintile should earn in average 360,000 Colones per semester and 2,160,000 Colones in a period of six semesters (comparable with the 0 to 5-year period simulation results presented in Table 3.7). The average plot size included in this survey was 8 hectares, therefore we are estimating in average a salary of 270,000 Colones per hectare as the minimum salary farmers should earn according with the national statistics (equivalent to 18 USD of 2003 per hectare per month).

This interpretation is used in Table 3.7 to estimate the percent of probability that a farmer can earn a salary above the minimum level. In this case, certainty levels indicate the probability a farmer has of achieving a profit above the minimum level considered for Costa Rica. For the domestic price scenario, there are a 100% probability farmers can earn a profit above the minimum and there is only a 9.20% certainty farmers will do the same under the international price scenario. These conclusions provide evidence of the strong effect that the application of a tariff on imported rice has on the level of profitability associated with the rice production around Palo Verde, Costa Rica.

Figures 3.4 and 3.5 display probability distributions for profits under the two scenarios. All values within 2.6 standard deviations are included, which represents approximately 99% of the forecast values. Certainty levels are also indicated in the charts. Figures 3.6, 3.7 and 3.8 show a series of overlay charts. These charts superimpose frequency data from the profit forecast under the two rice price scenarios.

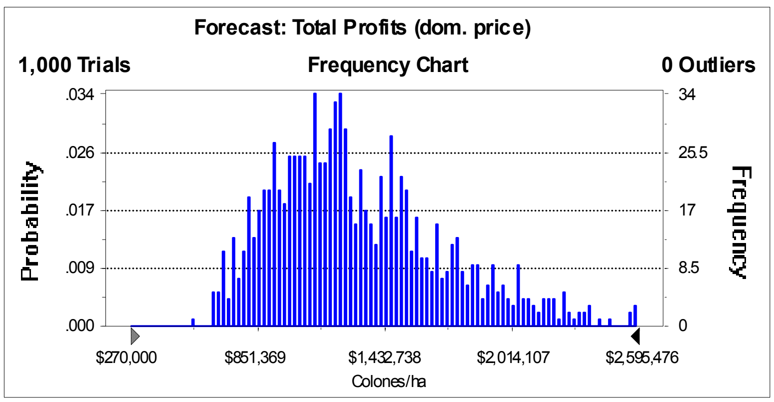

Figure 3.4. Probability distributions of profit for rice production around Palo Verde considering the domestic price of rice. Likelihood of achieving a profit comparable with the minimum salary = 100%.

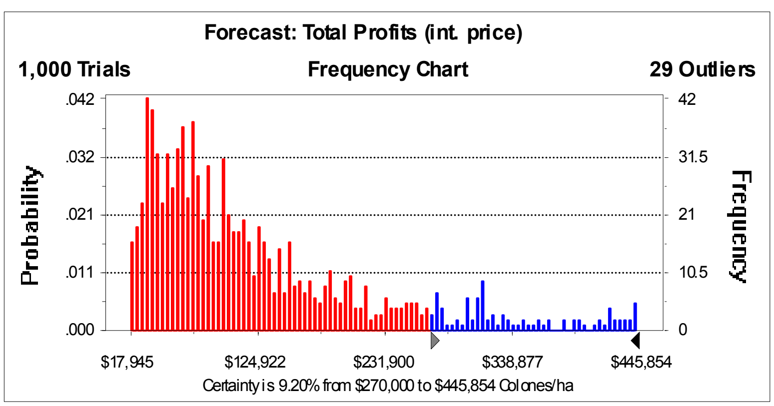

Figure 3.5. Probability distributions of profit for rice production around Palo Verde considering the international price of rice. Likelihood of achieving a profit comparable with the minimum salary = 9.2%.

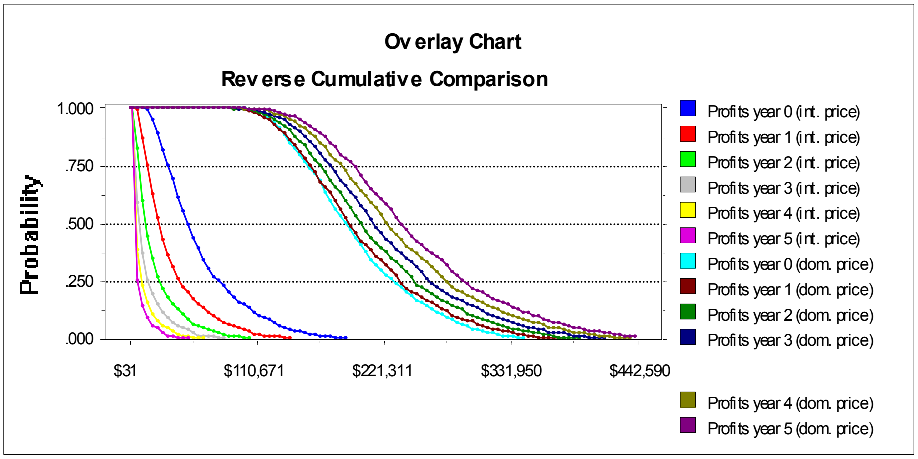

Figure 3.6. Reverse cumulative distributions for profits of rice production. Distributions from both scenarios are shown in the chart.

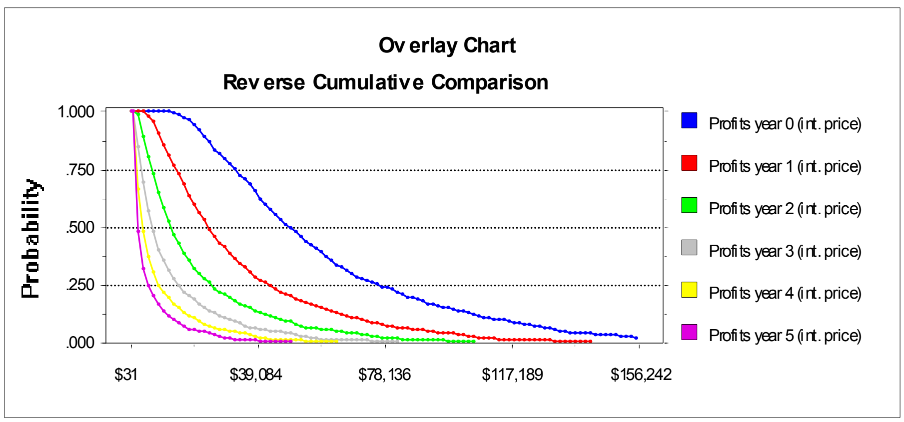

Figure 3.7. Reverse cumulative distributions for profits of rice production. Distributions from the scenario that considers the international price of rice is shown in the chart.

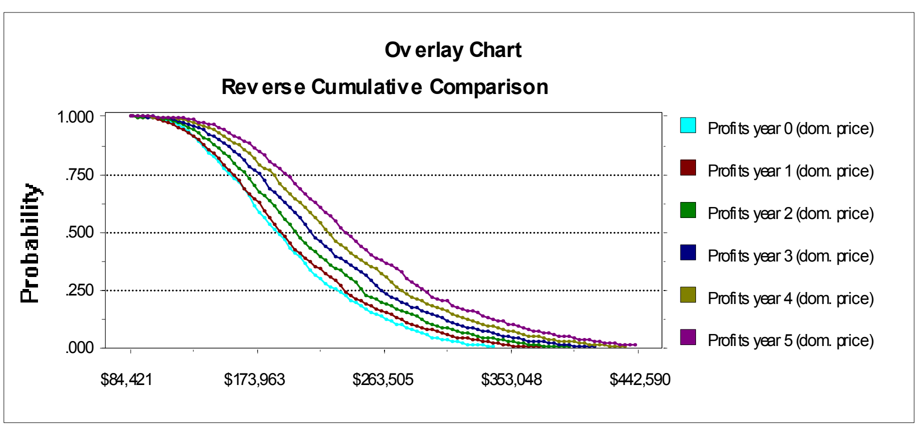

Figure 3.8. Reverse Cumulative distributions for profits of rice production. Distributions from the scenario that considers the domestic price of rice is shown in the chart.

Figures 3.6, 3.7 and 3.8 show the reverse cumulative distribution of the profits forecast presented in Table 3.7. In these charts, the height determines the probability that the variable falls at or above the associated profit value. Figure 3.6 shows how distributions among the two price scenarios are related to each other. Distribution shape for the domestic price scenario is clearly dominant (located farther to the right) which suggests that farmers can expect a much higher level of profitability when facing the domestic price of rice. Farmers that cultivate rice around Palo Verde would much prefer a scenario with a tariff on imported rice, which should be taken into consideration if we consider that Costa Rica will operate under a free trade agreement with United States (main exporter of rice for Costa Rica).

Figure 3.7 and 3.8 shows the trends in a 5-year period of the level of profits. For the case of the international price scenario (Figure 3.7) the tendency is the decreasing of profitability where year 0 is further to the right. For the domestic price scenario the tendency is the increasing of the level of profitability, because in this case year 5 is further to the right.

In general, the objective of the simulations was to quantify the potential for profits given the characteristics of every price scenario and the features of the rice production around Palo Verde. Extreme values, as presented in Table 3.6, were generated for every variable with the goal of incorporating the worst and the most optimistic conditions under which a farm would operate, according to information collected during the interviewing process and the collection of secondary data. However an important limitation of the results presented in Table 3.7 is related with the functional form used to define profits as presented in the previous section and according with the results of Table 3.5. The use of a log-log profit function limits the results to only positive numbers (the log of a negative number is undefined), restricting the chance of determining the percentage of farmers that actually could earn a negative profit. Figures 3.4 and 3.5 show the probability distributions associated with only positive profits, although they clearly present the greater potential for bigger profits for the case of the domestic price scenario.

3.5. Conclusions

This chapter estimated the profit function associated with rice production in Bagatzi, Falconiana and La Soga, agricultural communities located around the Palo Verde National Park in the Guanacaste Province of Costa Rica. This information is important to understand the structure of the rice production and to know the variables that influence the level of profitability in this particular region. These results were also used to simulate future profits under conditions of uncertainty and considering different rice price scenarios.

Regarding the profit function, the empirical results suggest that price of rice seed, and capital intensity are the variables that most affect the level of profitability. No statistically significant results were obtained in relation to the price of fertilizers, irrigation or family size, and the community dummy variable (proxy for soil quality) was significant only at the 20% level. Given that the capital intensity is expressed as the sum of costs of pesticides, herbicides, machinery and transportation, these results show the great impact of these factors on the level of profitability. This may be especially true for pesticides and herbicides; because agronomic research has shown that the current seeds varieties used around Palo Verde are highly susceptible to pathogens and therefore require intensive chemical use. This result suggests that future research should gather more detailed information on availability, pricing, and use of specific agrochemicals (especially pesticides and herbicides).

Farmers usually must choose between a seed variety that is more productive but also more susceptible to diseases or a variety that is more resistant but less productive.

Given that the particular definition of profit was defined based on the number of significant variables and its coefficient of determination, other functional forms can obtain different results.

Given our small sample size (40 households included in the survey) and the limited variation among these farmers, it is not surprising that the profit model explains only 31% of the variation. More data are needed to test the influence of other input prices, such as herbicides, insecticides and fungicides, which are used intensively in the study area. The structure of the local labor market should also be investigated. Wage could be another important input price. The use of external workers in some cases can be very intensive depending mainly on the variety of seeds used that determines the more or less intensive use of agrochemicals.

4. Estimation of a fertilizer demand function associated with rice production around Palo Verde, Costa Rica

4.1. Introduction

High intensity use of agrochemicals (fertilizers, insecticides, fungicides and herbicides) characterizes the agricultural production in the Guanacaste Province of Costa Rica. This situation is particularly sensitive around the Palo Verde National Park, which is located downstream from the Arenal-Tempisque Irrigation District.

This irrigation system currently irrigates about 20,000 hectares of agricultural land, which is mainly planted to rice and sugar cane. Most of the farmers associated with the Arenal-Tempisque Irrigation Project area small landowners, being beneficiaries of the state land reform that provided 7-10 hectare of mainly rice-growing plots. The availability of irrigation has caused a shift from traditional to intensive cultural practices, with a sharp increase in the use of fertilizers and pesticides. This in turn has resulted in increased levels of nitrates, phosphates and other chemicals in the drainage water. Another problem is the use of mechanized land preparation methods for rice planting that lead to high soil sediment content in the drainage water. Soil sediments are contributing to the degradation of the wetlands located inside Palo Verde (Hazell, 2001).

Declining water quality from an increase in chemical and soil sediment loading in the runoff from the irrigation district has in recent years become a cause of major concern for the Costa Rican Government. This has come about not only through increased awareness at various levels but also from discussions with the Interamerican Development Bank which has made water quality a key component of loan provisions to finance further infrastructure construction (Hazell, 2001).

This chapter estimates a fertilizer demand function that explain the factors influence the amount of fertilizers farmers use to cultivate rice in three agricultural communities around Palo Verde. This study examines the level of demand for fertilizer recognizing that input and output prices, fixed factors, and soil conditions may vary among farmers and communities.

At the same time, by identifying the variables that influence the amount of agrochemicals (e.g. fertilizers) used in rice production, this analysis can support the formulation of incentives or alternatives that promote better use of these products. The profit function estimated in the previous chapter and conditional demand function for fertilizer provide insight on how farmers will respond to policy instruments such as fertilizer taxes and rice production constraints. In combination with better information on the impact of agrochemicals on the wetlands of Palo Verde from other studies, these results will help design policies to encourage more efficient and more environmentally friendly use of agrochemicals.

4.1.1. *Fertilizer use in rice cultivation in Costa Rica and around Palo Verde*

In Costa Rica, rice cultivation started as a subsistence activity developed by small farmers. Cultivation involved the use of local rice varieties highly susceptible to pests and with low response rate to fertilizers (Vargas, 1971 cited by Perez, 2002).

In the last two decades, new varieties with high productivity levels were developed and introduced to farmers by the Rice National Program. Since 1991, national rice productivity has remained constant and even decreased, with the exception of some small producers in Bagatzi where farmers have obtained yields of eight tons per hectare, but only in small areas an at high cost (Cordero 1993a cited by Perez, 2002).

In 1961, Costa Rica established the Technical Assistance Program for Cultivating Rice. This program has given information to farmers about optimal levels of fertilizers (N, P, K, S and Zn). In the same year, a program of chemical pest control was also initiated. One of the main current goals of this program is to achieve an appropriate and efficient use of agrochemicals, given that its irrational application has increased the use of these products to more than 20% of the total costs of rice production (Aguero, 1996 cited by Perez, 2001). Figure 4.1 shows the trend in the use of fertilizer in agriculture in Costa Rica between 1990 and 1999. This graph shows the increasing rate of fertilizer use. In 1999, 395% more fertilizer was used compared with the level of consumption in 1990.

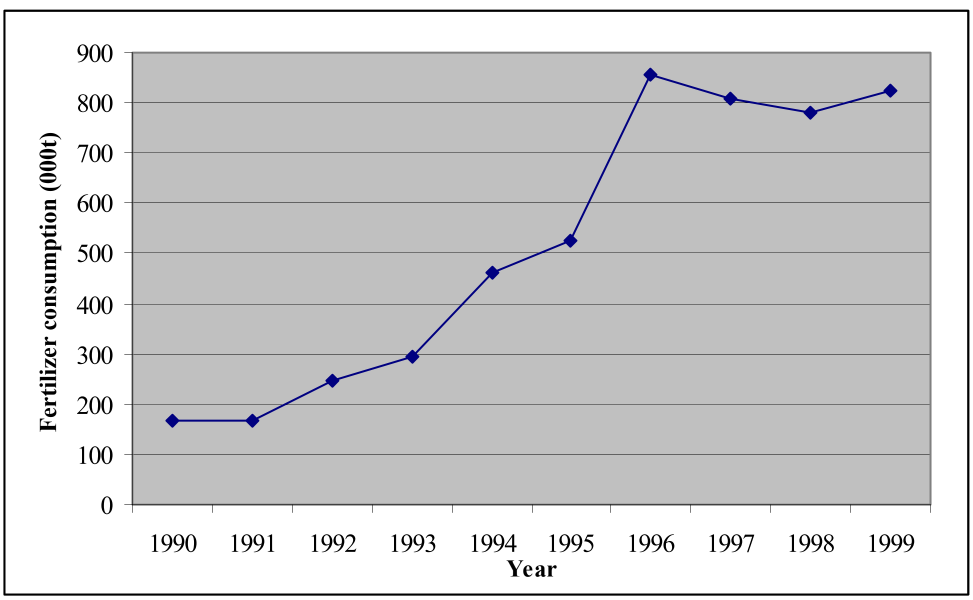

Figure 4.1. Total consumption of fertilizer in Costa Rica

4.1.2 *Arenal-Tempisque irrigation project (PRAT)*

The Arenal-Tempisque irrigation project was conceived between 1975 and 1978. Water from the cloud forest of Arenal is used to feed into the largest hydroelectric project in Costa Rica and is later used by the largest irrigation project in Central America. Currently 20,000 ha are under irrigation, benefiting close to 800 producers. Figure 4.2 shows the different water flows that take place around the Arenal-Tempisque watershed.

The upper part of the catchments is characterized by a large area of cloud forest, rich in biodiversity, competing among other land uses especially in the form of livestock (dairy and meat), and agriculture. Water is stored in the Arenal Reservoir, an inter-annual artificial lake created to feed into a system of three hydroelectric plants arranged in cascade (known as the ARCOSA system), which provides over a third of the electricity produced in the country. From the hydroelectric power system, water flows through a private fish farm and an area of intensively irrigated farms, mostly dedicated to rice and sugarcane plantations, before draining into the Palo Verde National Park, an important wetland that hosts a large population of migratory birds. The wetland serves as a filter for water that drains into the Gulf of Nicoya, one of the most productive estuary ecosystems in the world, which accounts for approximately 20 percent of the total fisheries harvest in Costa Rica (Hazell, 2001 and Aylward, 1998).

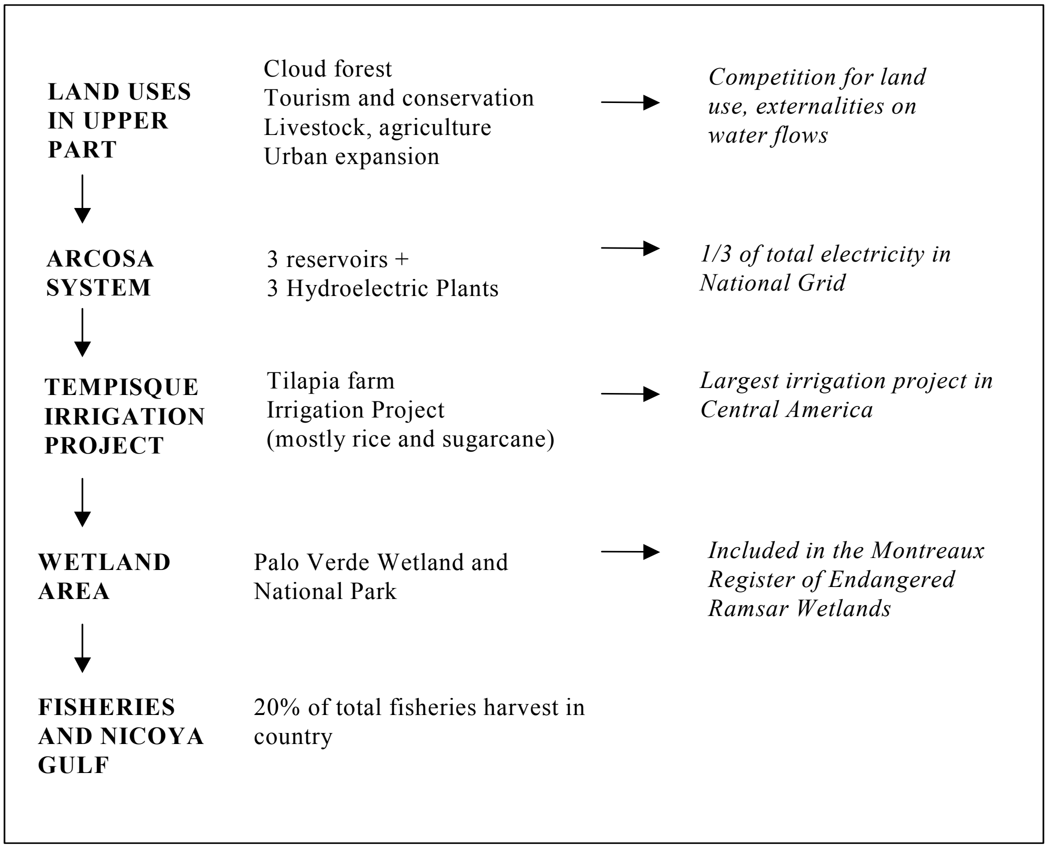

Figure 4.2. Water flows in the Arenal-Tempisque watershed (CLUWRR, 2004)

During the first phase of construction, the 6,000 ha reservoir and irrigation project cost $19.8 million to develop. A second phase of the irrigation project cost around $45.4 million. The annual operation and maintenance cost is estimated at $55/ha. During 2003, farmers must pay approximately 8,600 Colones per hectare twice a year for receiving irrigation.

This important governmental investment has provoked an important expansion of the rice cultivation within the boundaries of the Guanacaste Province (Perez, 2000). However, among the negative impacts of the rice production, the loss of soils and the water contamination with agrochemicals appear to be the most critical ones (Mc Coy, 1994 cited by Mc Coy, 1998). PRAT has provoked an important increasing in the cultivation of rice with a sharp increase in the use of fertilizers and pesticides. This in turn has resulted in increased levels of chemical fertilizers in the drainage water. The problem is aggravated by the continued use of early high-yielding varieties of rice that have poor pest resistance and need more frequent spraying (Hazell, 2001).

Considering the estimation of the fertilizer demand function, this chapter will also analyze the impacts of the Arenal-Tempisque irrigation project and future trends in fertilizer consumption using the variables that explain its demand, including different policy alternatives to promote a more efficient use of these chemicals and avoiding the externalities that agricultural runoffs have on the wetlands of Palo Verde.

4.2. Conceptual model

4.2.1. *Factor demand function*

In the estimation of input demand and output supply, different approaches have been suggested and adopted. Timmer (1974), cited by Chembezi (1990), identifies two approaches –direct and indirect estimation. Indirect approaches include deriving demand functions from agronomic response functions and research. Direct methods include estimating demand functions directly from observed market data on input consumption and prices, and the prices of farm output. For the purpose of this study, the direct method approach will be used to estimate the fertilizer demand function associated with rice production around Palo Verde, Costa Rica.

Differentiating the profit function with respect to output price yields output supply, while differentiating it with respect to price of a particular factor yields (the negative of) the corresponding factor demand. Hotelling-Shephard's Lemma shows the relationship between the profit function of equation (2) of Chapter 3 and the factor demand. By applying the lemma to (2) of Chapter 3, the variable input demand function are obtained as

$$\frac{\partial \Pi \,(W,Z)}{\partial W_i} = -X_i^* \,(W,Z) \qquad (1)$$

where factor demand (e.g. fertilizers demand) is a function of output and input prices, and fixed factors.

Conditional factor demand is a function that gives the optimal demand for each of several inputs as a function of the output expected, and the prices of inputs. Conditional demand functions are obtained using the Shepard's Lemma where the cost minimization problem is the production of a specified level of output with the least expenditure on inputs.

By Shepard's Lemma the firm's system of cost minimizing input demand functions (the conditional factor demands) may be obtained by differentiating the cost function with respect to input prices:

$$X_i\,(y,w_i) = \frac{\partial c(y,w_i)}{\partial w_i} \qquad (2)$$

where X_i is the quantity of input i used at factor prices, w, when y units of output are made in the least cost function. In this case (and in difference with equation (1)), w does not include output price. Given that information on production was collected for every farmer included in this study, the conditional factor demand approach will be used to estimate the fertilizer demand.

The functional form for conditional factor demand can be derived consistent with an assumed production function, but in this study we are estimating a reduced form with no cross-equations restrictions. The fertilizer demand will be specified directly using a fertilizer demand function that includes output quantity, input prices, and fixed factors. If these independent variables are the sole determinants of fertilizers use, then the equation will be homogeneous of degree zero. This is achieved by dividing all the prices in (6) by one of the prices. However Chavas (1980), cited by Chembezi (1990, page 301), states "if careful attention is given to model specification, it appears that homogeneity restrictions should not be imposed on supply response models unless the excluded prices are known to have little influence on production decisions".

The estimation of a fertilizer demand will provide important information on the factors that influence the fertilizer use associated with rice farming in Bagatzi, Falconiana and La Soga located around the Palo Verde National Park, Costa Rica.

The parameters of the fertilizer demand function are estimated by single equation Ordinary Least Squares (OLS) procedure. One concern in terms of estimation problem is the simultaneous nature of the relationship between fertilizer demand and the price of fertilizer. According with Chembezi (1990), the simultaneous relationship would preclude the application of OLS to the equation in that OLS estimates will be biased and inconsistent. However, fertilizer prices in Costa Rica are announced in advance of the planting season. Farmers base their decisions about quantities of inputs on those prices. The prices of fertilizers over a short period of time are unaffected by aggregate demand in the study area within the same period.

4.2.2. *Evaluation of fertilizer demand and policy analysis*

The estimation of the fertilizer demand function using the methodology presented in the previous section will permit to identify the significant variables that explain its consumption. As in the previous chapter, these results will be used to estimate a new fertilizer demand function using only the significant variables. This new fertilizer function will serve the purposes of risk analysis with Crystal Ball™. This simulation will provide information about future trends in fertilizer consumption.

In the estimation of future fertilizer consumption, future variations in price of domestic rice, price of imported rice and price of fertilizers were estimated based on secondary data on prices obtained from the Costa Rican Rice Office, FAO and IRRI. The estimation of future prices will be treated in the same way as presented in the previous chapter. For the case future fertilizer price OLS regression analysis will be used using as dependent variable the price and the independent the year.

4.3. Data sources

As was the case in Chapter 3, the data used to estimate the fertilizer demand function will be the same. Again, production data from 40 farmers in the communities of Bagatzi, Falconiana and La Soga are included. The variables required to estimate the fertilizer demand function are input prices (seeds and fertilizer), output (rice) production and quantities of fixed factor inputs (land, irrigation cost, family size, and land preparation). Table 4.1 shows the descriptive statistics of the variables included in this analysis. The coefficients of variation suggest that there was enough variation across farmers to permit statistically significant parameters to be estimated. The high variation in land area is explained by the presence of farmers that rent land from other farmers and therefore are able to cultivate larger areas (rental payments were not subtracted from profits and rental land is not included in Z_1). Land preparation varies depending on the more or less intensive use of tractors during the *fangueo*, or mechanical mixing of soil to improve the soil structure and eliminate weeds.

Table 4.1. Descriptive statistics of variables included in the fertilizer analysis

Variable	Description	Mean***	Standard deviation	Coefficient of variation (%)
Y	Rice output (quintals*/ha*semester)	106.9	32.2	30.12
F	Fertilizer demand (quintal/ha*semester)	10.3	2.9	28.47
W_1	Price of rice seeds (Colones**/quintal)	9,769	861	8.81
W_2	Price of Fertilizers (Colones/quintal)	4,864	1,253	25.78
Z_1	Land (hectares)	10.8	10.1	93.82
Z_2	Cost of irrigation (Colones/ha*semester)	8,959	1,017	11.35
Z_3	Family size (number of people)	4.7	2.1	46.34
Z_4	Cost of land preparation (Colones/ha)	27,939	7,555	27.04
D_c	Community dummy variable = 1 if farmer cultivates in Falconiana and zero otherwise	0.20	0.40	---

* 1 quintal = 46 kilograms
** 1 USD = 427 Colones
*** Including 40 households of Bagatzi, Falconiana and La Soga

In the second chapter, no statistically significant differences were found among farmers of Bagatzi, Falconiana and La Soga (the three communities included in this analysis) on the variables shown in Table 3.3. However, a dummy variable for farmers of Falconiana was included to test for differences in fertilizer use. Personal communications with several specialists in this area suggested that Falconiana is characterized by higher soil quality.

4.4. Empirical Results

4.4.1. *Fertilizer demand function*

The empirical specification of the fertilizer demand is given by

$$\ln F = \ln C + \zeta_c D_c + \Omega \ln Y + \sum_{i=1}^{2} \alpha_i \ln W_i + \sum_{i=1}^{4} \Psi_i \ln Z_i \quad (3)$$

where F is the amount of fertilizer used in quintals per hectare (1 quintal = 46 kilograms), C is the constant, D_c is a dummy variable taking on the value of one for farmers located in Falconiana; Y is the rice output (quintals/ha); W_1 is the price of rice seeds; W_2 is the price of fertilizer; Z_1 is land; Z_2 is the irrigation payment (proxy for financial management skills); Z_3 is family size; Z_4 is cost of land preparation (index of capital intensity of technology).

The functional form for the conditional factor demand presented in (3) is assuming a Cobb-Douglas production function given by

$$Y = A \prod_{i=1}^{n} X_i^{\beta_i}, \ \beta_i > 0, \ i = 1,2,\ldots,n \quad (4)$$

where X_i is a vector of inputs represented by fertilizer, the dummy variable, rice seed price, fertilizer price, land, irrigation payment, family size and land preparation. Cobb-Douglas assumes that all the inputs used in rice production are essential.

According with the functional form presented in (3), we should expect a positive impact given by the community dummy (proxy for soil quality), and a negative impact of fertilizer price. Following the cost minimization problem, output quantity (Y) should have a positive impact on fertilizer demand. Fixed inputs should have a positive impact (land, financial skills and family size) and land preparation should negatively impact the use of fertilizer.

The parameter estimated for the fertilizer demand function is showed in Table 4.2.

Table 4.2. Estimation of the fertilizer demand function for rice production around Palo Verde, Costa Rica

Independent variables	Parameter	Estimated coefficient (OLS)	Standard error	P-value
Fertilizer demand function constant	ln C	-14.175	6.731	0.043
Y Output quantity	Ω	0.356^{++}	0.176	0.052
W_1 Seed price	α_1	1.908^{+++}	0.539	0.001
W_2 Fertilizer price	α_2	-0.456^{+}	0.296	0.133
Z_1 Land	Ψ_1	0.049	0.085	0.562
Z_2 Irrigation cost	Ψ_2	0.222	0.436	0.613
Z_3 Family size	Ψ_3	0.047	0.099	0.635
Z_4 Land preparation	Ψ_5	-0.095	0.147	0.521
D_c Community dummy	ζ_c	-0.258^{+}	0.134	0.063
N	40			
R^2	0.455			
Adjusted R^2	0.314			
F-value	3.24			0.008

$^{+}$ Statistically significant at the 15% level
$^{++}$ Statistically significant at the 5% level
$^{+++}$ Statistically significant at the 1% level

The estimated coefficient for the fertilizer price is negative which means that farmers tend to apply less fertilizer when the price is higher, although this variable was found significant only at the 15% level. During the interviews, almost all the farmers said that they are more or less insensitive to the price of fertilizers because they see this input as an essential factor to get a good harvest at the end of the season. However, according to these results, farmers do tend to reduce the use of fertilizer when its price increases.

The coefficient on seed price is positive and significant at the 1% level. One interpretation is that fertilizer and seed are substitute inputs. Another possibility is that in this area, the price of seed indicates quality, as varieties that are more resistant to pests are more expensive. These same varieties require more fertilizer. The development of varieties that are resistant to diseases and that have diminishing response to fertilizer could help to reduce the use of agrochemicals. The positive influence of seed price on fertilizer demand could also be explained by a lack of information: local farmers that buy more expensive seeds may seek to protect their investments by applying more fertilizer with the idea of avoiding future harvesting losses and getting more productive harvests, but without clear information about the real fertilizer requirements for these seed varieties.

The community dummy is significant at the 15% level, as expected. The limited information on soils in this region shows that soil properties in Falconiana permit a higher intensity and diversified use. Field technicians have tested the soils and provided this information to farmers. Among the communities included in this survey, Falconiana is the community that registers the highest variety of crops (rice, watermelons, melons, onions, tomatoes and other vegetables) evidencing a better soil quality.

The estimated coefficient for output quantity is significant at the 5% level. Given the functional form used to estimate fertilizer demand (log-log), the estimated parameter coefficient indicates the elasticity of fertilizer use given changes in output quantity. In this case a 1 percent change in output (rice) quantity leads to a 0.356 percentage change in the use of fertilizers. This relationship could be used to determine the impact of production quotas or other rice policies on fertilizer use. This will be considered in greater detail in the next section.

According with Table 4.2, in overall only output production, fertilizer cost and capital intensity functions were significant. Capital intensity and seed price are the only significant variables for the fertilizer cost function. For the capital intensity, output quantity, seed price and the dummy resulted to be significant.

It is interesting to note that for the case of fertilizer cost, the seed price is again the significant variable together with the intensive use of pesticides and herbicides (given by capital intensity). For the case of the capital intensity function, seed price is significant which is telling that the intensive use of capital (including pesticides and herbicides) is affected by the rice seed price.

According with Table 4.2, the estimated fertilizer demand function is significant at the 1% level and explains almost 46% of the variation in the use of fertilizers among farmers that cultivate rice around the Palo Verde National Park in Costa Rica. Given the small sample size, this result can be considered as a good model of fertilizer use.

An issue of central interest to policy makers is the responsiveness of output supply and factor demands to price policy, and how they are affected by investment and land polices (Lau and Yotopoulos, 1979 cited by Adesina and Djato, 1996). A summary of the elasticities derived from the single fertilizer demand estimation at the means of the variables is presented in Table 4.3. These results are consistent with predictions of theory and previous studies. Fertilizer demand is fairly inelastic (-0.456), which makes sense given the few substitutes that farmers have for chemical fertilizers. This is an important finding when considering fertilizer price as a policy mechanism to discourage the use of fertilizers in this particular region of Costa Rica.

The cross price elasticity with respect to the price of rice seed is fairly elastic (1.908). This is consistent with the previous explanation of the possible relationship between quality of seeds and fertilizer demanded (farmers tend to "protect" their investments when they use higher quality seeds). This is also an important consideration that should be taken into account when designing better policies to promote a more efficient use of fertilizers. The introduction of improved seeds varieties that are less responsive to high levels of fertilizer application can help to reduce the use of fertilizers to grow the rice and therefore reduce the environmental impact of these chemicals on the wetlands of Palo Verde.

If we consider the unconditional fertilizer demand, we could estimate the elasticity of fertilizer consumption with respect to the output price. Through this alternatives policy scenarios could be considered: taxing rice output or reducing the tariff applied on imported rice.

Table 4.3. Estimated fertilizer demand elasticities

Variable	Elasticity
Price of fertilizer	-0.456
Price of rice seed	1.908

4.4.2. *Alternative empirical approaches*

In the estimation of input demand, there are alternative ways to estimate factor demands for fertilizer and other important inputs.

First, if we consider the unconditional fertilizer demand function that incorporates rice price, this functional form does not provide very satisfying results because the estimated coefficient for output price is not significant (this unconditional form was tested when estimating fertilizer demand in the previous section). Likewise, in model of output supply presented in Table 4.4, output price is not significant. This is surprising and perhaps due to multicollinearity (given the high R^2) and uncertainty about the output price (as compared to the price of seeds). Several studies have shown that fertilizer demand is mainly affected by its own price and by output prices. In this case, more data are needed to infer the real effect of rice price on the use of fertilizers, the small variability in output prices also impede to conclude about the effect that output prices have on fertilizer demand.

Table 4.4 shows the cost-share functions of the inputs considered in this study and involved in rice production around Palo Verde, Costa Rica.

Table 4.4. Output supply and cost-share functions for rice production around Palo Verde, Costa Rica

Explanatory variable	Dependent variables: Output production	Seed cost	Fertilizer cost	Capital intensity	Hired labor
Constant	4.381 (6.383)	9.427 (2.015)[a]	-12.145 (5.710)[b]	-3.239 (5.180)	-114.488 (79.903)
Y Output quantity	—	-0.034 (0.085)	-0.064 (0.187)	0.564 (0.133)[a]	3.561 (2.593)
W_1 Seed price	-0.727 (0.450)[c]	—	1.501 (0.473)[a]	0.826 (0.403)[b]	2.511 (6.800)
W_2 Fertilizer price	-0.171 (0.242)	0.197 (0.115)[c]	—	0.034 (0.222)	1.549 (3.510)
P_y Output price	0.107 (0.412)	—	—	—	—
Z_1 Land	0.030 (0.070)	0.061 (0.033)[c]	0.033 (0.069)	-0.003 (0.064)	0.862 (1.008)
Z_2 Irrigation cost	-0.061 (0.388)	-0.205 (0.181)	0.128 (0.385)	0.392 (0.336)	8.018 (5.245)
Z_3 Family size	0.030 (0.086)	-0.027 (0.040)	0.062 (0.088)	0.050 (0.078)	2.238 (1.181)[c]
Z_4 Land preparation	0.000 (0.000)	0.015 (0.060)	-0.070 (0.128)	0.093 (0.113)	2.623 (1.761)
Z_5 Hired labor	0.015 (0.012)	0.003 (0.006)	-0.018 (0.012)	-0.011 (0.011)	—
Z_6 Capital intensity	0.657 (0.159)[a]	0.102 (0.090)	0.767 (0.204)[a]	—	-3.007 (2.839)
D_c Community dummy	0.161 (0.122)	0.071 (0.059)	-0.107 (0.126)	-0.288 (0.100)[a]	-1.676 (1.776)
N	40	40	40	40	40
R^2	0.496	0.254	0.659	0.564	0.304
Adjusted R^2	0.322	0.030	0.557	0.434	0.095
F-value	3.24[a]	1.14	6.46[a]	4.32[a]	1.46

Figures in parenthesis are standard errors
[a] Statistically significant at the 1% level
[b] Statistically significant at the 5% level
[c] Statistically significant at the 15% level

4.4.3. Fertilizer demand and policy lessons

Crystal Ball results and future fertilizer consumption

The empirical specification of the fertilizer price functions is given as

$$\ln FP^{3} = \lambda \ln C + \theta \ln Year \qquad (3)$$

where FP is the price of fertilizer, and C is the intercept.

With the results of (3), the % change in price of fertilizers will be determined based on the relationship given by

$$\% \text{ change in price of fertilizer} = (e^{\theta}-1)*100 \qquad (4)$$

Results of (4) will be used together with the % change in domestic and international price of rice estimated in the previous chapter.

Table 4.5 summarizes the choice of probability distributions and the correspondent values selected as distribution parameters. Table 4.5 also shows the assumptions used for the international price to analyze different price scenarios. The probability distribution for capital input and rice production was based on the data collected during the field interviews in Bagatzi, Falconiana and La Soga developed during the summer of 2003 by the author.

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[3] lnFP = 207.810 – 0.099 Year (R^2 = 0.698)

Table 4.5. Assumptions used for the risk analysis of rice production around Palo Verde

Fertilizer Demand Function				
Variable	Unit	Distribution	Parameter	Value
Intercept (ln C)	Number	Normal	Minimum	-26.34
			Maximum	1.97
Rice production	Quintals*/ha	Normal	Minimum	52
			Maximum	199
Rice production parameter (Ω)	Number	Normal	Minimum	-0.10
			Maximum	0.86
Seed price parameter (α_1)	Number	Normal	Minimum	0.45
			Maximum	3.39
Fertilizer price parameter (α_2)	Number	Normal	Minimum	-1.33
			Maximum	0.29
% change fertilizer price	%/100	Normal	Minimum	-0.13
			Maximum	-0.7
% change seed price	%/100	Normal	Minimum	0.02
			Maximum	0.08
Community dummy parameter (ζ_c)	Number	Normal	Minimum	-0.60
			Maximum	0.12

* 1 Quintal = 46 kilograms

The policy analysis associated to the fertilizer consumption around Palo Verde will be treated assuming different policy scenarios:

i. This scenario will assume that the Costa Rican Government mandates to use less fertilizer.

ii. This scenario will assume the imposition of a tax on the consumption of fertilizer.

iii. This scenario will assume a control over the rice production.

This scenario will consider fertilizer consumption differences among communities using a community dummy as a proxy for soil quality.

The estimates of the fertilizer demand function presented in the previous section determined that only seed price, output quantity, the community dummy, and fertilizer price were significant at the 1%, 5%, 5% and 15% level respectively. Using these results, a new OLS regression analysis was developed to determine a new fertilizer demand function using only these statistically significant variables. With this new function, the fertilizer demand around Palo Verde was analyzed under conditions of risk and uncertainty. Table 4.6 shows the new estimates for the fertilizer demand function that will be used in Crystal Ball to simulate future fertilizer consumption among farmers grouped according to the community dummy (in this case farmers of Falconiana will define one risk simulation scenario an the rest the other one).

Table 4.6. New estimates of the fertilizer demand function for rice production around Palo Verde, Costa Rica. Only significant variables determined in previous section were included.

Independent variables	**Parameter**	**Estimated coefficient (OLS)**	**Standard error**	**P-value**
Intercept	ln C	-12.679	4.885	0.013
Y Output quantity	Ω	0.378^{++}	0.158	0.022
W_1 Seed price	α_1	1.922^{+++}	0.488	0.000
W_2 Fertilizer price	α_2	-0.516^{+}	0.271	0.065
D_c Community dummy	ζ_c	-0.236^{++}	0.117	0.050
N	40			
R^2	0.436			
F-value	6.77			0.000

$^{+}$ Statistically significant at the 15% level
$^{++}$ Statistically significant at the 5% level
$^{+++}$ Statistically significant at the 1% level

Simulation results will present information to show future trends in fertilizer consumption. Given the fertilizer demand presented in Table 4.6, trend evolution in output produced, fertilizer price and seed price can depict the future consumption of fertilizer in the agricultural communities around Palo Verde that were included in this study. Specifically, the relationship between output quantity and fertilizer demand will be also incorporated in the policy discussion.

The analysis of fertilizer demand will be based on both the results of the 5-year period simulation and the results presented in Table 4.6. For the simulation process, we defined two scenarios where the first one represent farmers of Bagatzi and La Soga, and the second one represent farmers of Falconiana. We are making this difference to test the influence of the dummy variable in the fertilizer demand function presented in the previous section.

The results of the fertilizer consumption simulation are presented in Table 4.7. These results are based on the forecast range between range minimum and maximum. These ranges were arbitrarily defined based on the field data collected during the interviews. The certainty levels represent the probability of using a quantity of fertilizer greater than the current average use in this region (11 quintals/ha).

Table 4.7. Forecast parameter and statistics generated from Monte Carlo simulation (1,000 iterations) of fertilizer consumption around Palo Verde, Costa Rica

Forecast	Unit	Parameter	Community dummy scenario	
			Bagatzi and La Soga	Falconiana
Fertilizer consumption (5-year period)	Quintals*/ha	Mean	10	11
		Median	5	6
		St Dev	10	10
		CV (%)	100	90.91
		Range minimum	1	1
		Range maximum	36	36
		Certainty level	32.99%	35.86%
		Certainty range	11 to 36	11 to 36

* 1 Quintal = 46 Kilograms

For both scenarios there is close to a 30% probability of using an amount of fertilizer greater than the current use in this region. Figures 4.3 and 4.4 show the probability distribution of fertilizer consumption considering only the display range between the range minimum and maximum presented in Table 4.7.

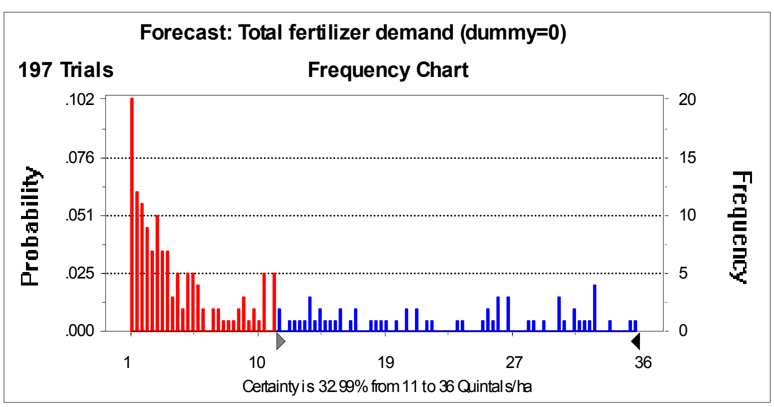

Figure 4.3. Probability distribution of fertilizer consumption considering only farmers of Bagatzi and La Soga. Likelihood of demanding more that 11 quintals/ha = 32.99%

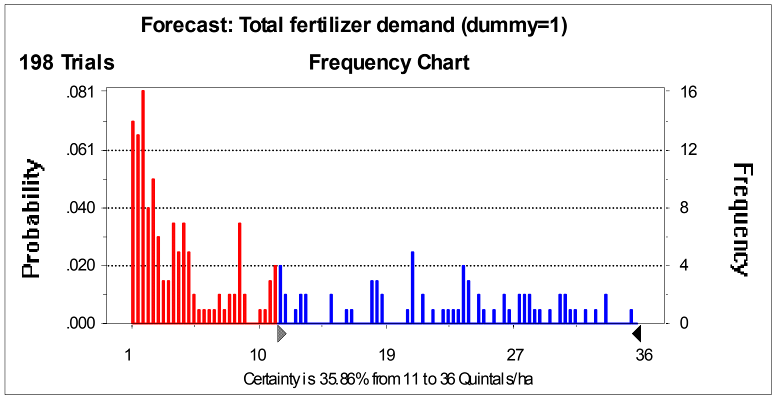

Figure 4.4. Probability distribution of fertilizer consumption considering only farmers of Falconiana. Likelihood of demanding more than 11 quintals/ha = 35.86%

As was the case with the profit function Figures 4.3 and 4.4 show the problem of using a logarithmic functional form for fertilizer consumption (undefined with negative number and extreme values with no practical meaning).

Figure 4.5 presents total fertilizer consumption considering the 5-year period and the two community scenarios. Figures 4.6 and 4.7 show the future trend in fertilizer consumption. According with these figures there is no a clear tendency of increasing or decreasing the use of fertilizer considering the three communities included in this study. Figure 4.6 also shows that there is no a clear difference between the two scenarios meaning that these three communities tend to use similar quantities of fertilizer (this community scenario was tested to check if soil quality could affect future fertilizer use in this area).

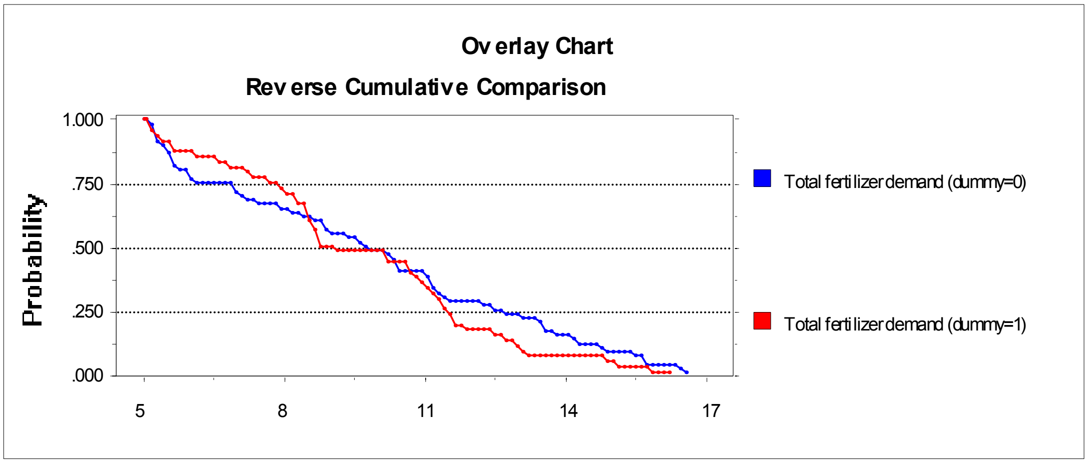

Figure 4.5. Reverse Cumulative distributions for fertilizer consumption. Distributions from both community scenarios are shown in the chart

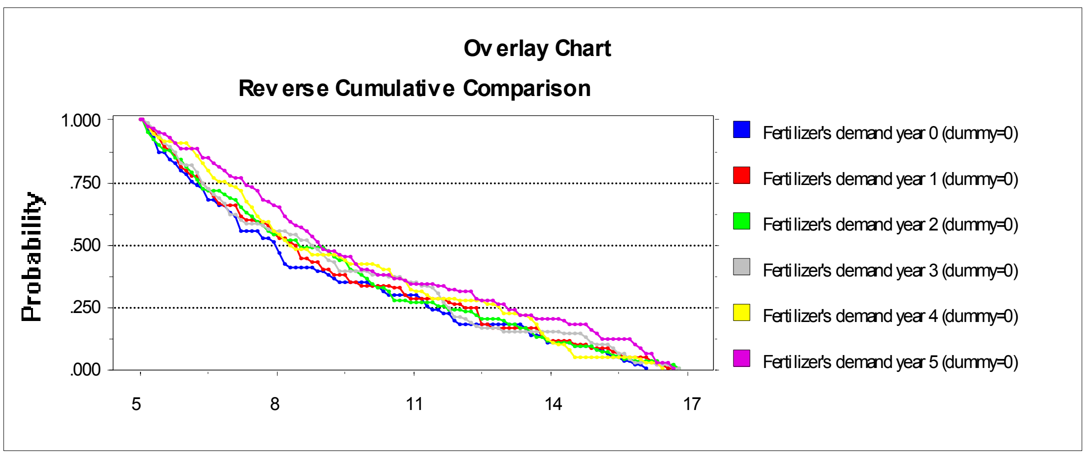

Figure 4.6. Reverse Cumulative distributions for fertilizer consumption. Distributions from the scenario that considers farmers of Bagatzi and Falconiana are shown in the chart

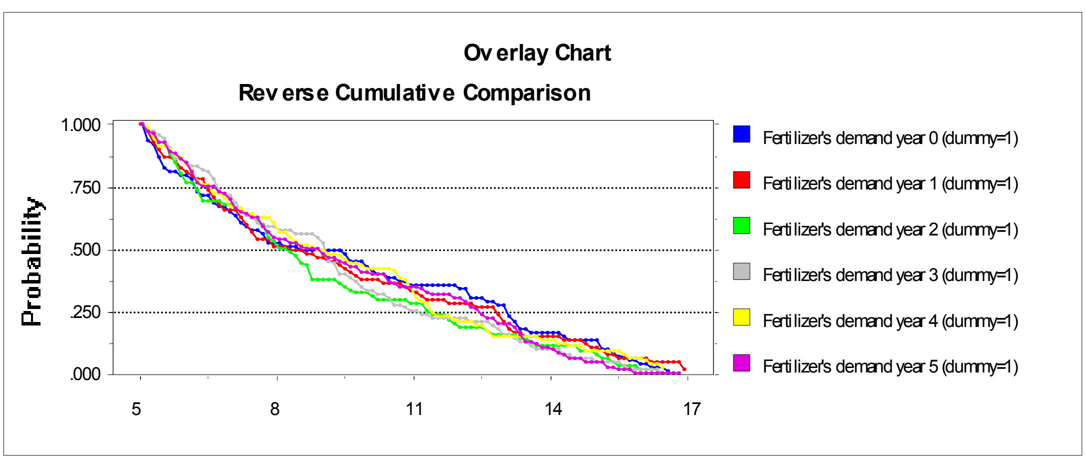

Figure 4.7. Reverse Cumulative distributions for fertilizer consumption. Distributions from the scenario that considers farmers of Falconiana are shown in the chart.

Policy analysis

Considering the different policy scenarios defined in Section 4.2.2, different implication on fertilizer use can be derived based on the results of this chapter.

i. Command and control: mandated reduction in fertilizer use

If we consider a policy scenario where the Costa Rican Government directly imposes a reduction in fertilizer consumption, important implications can be derived from the experiences in other countries and the current social and economical situation of Costa Rica. Previous experiences have concluded that due to high costs associated with enforcement and monitoring imposing a quantity restriction may not be feasible.

ii. Fertilizer tax: raising the price of fertilizer

In this policy scenario, we are assuming the imposition of a tax on fertilizer consumption, with the purpose of discouraging the use of fertilizers.

According with the results of Table 4.5, the empirical specification of the fertilizer demand associated with the rice production around Palo Verde is given by

$$\ln F = -12.679 - 0.236\ D_c + 0.378 \ln Y - 0.516 \ln W_2 + 1.922 \ln W_1 \qquad (4)$$

where F is the fertilizer consumption (Quintals/ha), Y is the rice output (Quintals/ha), D_c is the community dummy (proxy for soil quality), W_1 is the price of rice seeds and W_2 is the price of fertilizer.

Given the functional form (log-log) presented in (4), we can estimate the elasticity of fertilizer demand with respect to fertilizer price. According with this empirical specification, a 1% change in fertilizer price leads to a -0.516% change in fertilizer consumption.

Using the results of Table 3.4, we can estimate the percentage change in profits given a percentage change in fertilizer price. According with Table 3.4, a 1% change in fertilizer price leads to a -0.737% change in profits.

If the Costa Rican Government seeks to discourage fertilizer use, Table 4.8 shows different levels of fertilizer price as a result of the tax and the corresponding reduction in fertilizer consumption and profits.

Table 4.8. Economic impact of different levels of taxation on fertilizer consumption associated to rice production around Palo Verde, Costa Rica

% change in fertilizer price (tax)	Implied % of reduction in fertilizer use	Implied % of reduction in profits	Upper bound on the loss of profits (Colones*/ha)
6%	3%	4%	8,160
10%	5%	7%	13,600
19%	10%	14%	27,199
29%	15%	21%	40,799

*1 USD 2003 = 427 Colones

According with Table 4.8, the imposition of a tax on fertilizer use has more impact on profits than on fertilizer consumption given the few substitutes for fertilizer farmers have in this area. Different targets of reduction in fertilizer use leads to a different levels of taxation. This information can be used in the formulation of future policies seeking the reduction in fertilizer use through an increasing of its price. The upper bound on the loss of profits is estimated based on the data collected in the field (average farmer profits).

iii. Rice production quota: limiting production of rice

Another alternative to indirectly discourage the use of fertilizer in rice production around Palo Verde is through a restriction on rice production (quotas on output production).

According with (4), a 1% change in output quantity leads to a 0.378% change in fertilizer consumption. This is an important conclusion that can be used for the formulation of future policies that seek a reduction in fertilizer use or a compensation for the environmental damage that its use provokes on the wetlands of Palo Verde. If we consider this relationship, we can estimate the economic impact of the implementation of various reductions in rice production (quotas). Table 4.9 presents different policies tempting to get various levels of reductions in fertilizer consumption and the upper bound on the loss of revenues (given by the economic valuation of the reduction in output quantity for an average rice farmer of this area).

Table 4.9. Economic impact of different policies attempting to reduce the use of fertilizers in rice production around Palo Verde, Costa Rica

% of reduction in output production (quotas)	Implied % of reduction in fertilizer consumption	Upper bound on the loss of revenues (Colones*/ha)
8%	3%	32,038
13%	5%	53,411
26%	10%	106,832
40%	15%	160,312

*1 USD 2003 = 427 Colones

In this case, and according with Table 4.9, if the Costa Rican government wants to reduce the use of fertilizer in 15%, a quota on rice production of 40% has to be established. The same result in reduction of fertilizer use can be achieved by imposing a tax of 29% on fertilizer price.

Results of Table 4.9 can be interpreted in different ways:

- The economic valuation of the reduction in rice production can be considered as a subsidy that farmers should receive from the government for reducing fertilizer consumption.
- The economic valuation of the reduction in rice production can be considered as the amount farmers should pay for the environmental disservice fertilizer produces on the wetlands of Palo Verde. In this case farmers pay to avoid the reduction in fertilizer use.

Under this policy scenario, rather than apply a tariff, the government could chose to directly subsidize rice production. If it limited the amount of production it subsidized, this would essentially act like a quota – or a quantity control – on rice production.

The cultivation of rice in this region is now an intensive activity thanks to the irrigation; farmers can grow the rice twice a year instead of once a year as it was when they did not get access to irrigation. This water comes from the cloud forest on the Tempisque watershed and is canalized by the Arenal-Tempisque irrigation project. The watershed services provided by forests have been recognized in Costa Rica for a long time. Table 4.10 presents a detail of watershed services market initiatives in Costa Rica.

Table 4.10. Markets and Payments for Hydrological Services in Costa Rica

Service/Mechanism/Case	Status	Summary
1. Hydrological Services to Hydropower Production		
A. Transfer Payments: FONAFIFO and Hydropower Companies		
(i) Energia Global: Don Pedro and Rio Volcan Hydroelectric plant	Implemented and coming to a close, likely to be renewed	Company pays $10/ha/yr and FONAFIFO pays the remaining $30/ha/yr. FUNDECOR acts as intermediary. Over $43,000 were allocated during the first year. Contracts are for 5 years.
(ii) Hidroelectrics Platanar (1)	Ongoing implementation	Company pays $15/ha/yr and FONAFIFO the remaining $25/ha/yr. For landholders without land titles the Company pays $30/ha/yr. FUNDECOR and CODEFORSA are intermediaries. Contracts are for 5 years.
(iii) Compañia Nacional de Fuerza y Luz (3) – Aranjuez, Balsa and Cote	Ongoing implementation	Company covers the full amount of the payment ($40/ha/yr) plus expenses for FONAFIFO ($13/ha during the first year and $7/ha for the remaining years. Contracts are for 10 years. There is no other intermediary between the company and FONAFIFO.
B. Voluntary Contracts		
(i) Esperanza HEP and Monteverde Conservation League	Ongoing implementation	The agreement settles a dispute over some land where the hydroelectric plant is to be built, granting the right to the company to build and use the water during 99 years, after which infrastructure and land will be the property of MCL. Payments are made gradually starting with $3/ha during the first year, to $10/ha during the fourth year. After the amount of payment is variable and depends on production and sale price.
2. Hydrological Services to Water Supply		
A. Transfer Payments: FONAFIFO and Industry		
(i) Costa Rican Brewery	Agreed	The company (FLORIDA ICE & FARM) agreed to pay US$45/ha/yr for 1000 ha located in the watershed where their water originates. It also pays additional money to FONAFIFO and FUNDECOR to administer and monitor the programme. More recently it liaised with EHSP (see below) to pay for environmental services in overlapping areas.
(i) Melia Playa Conchal Hotel	Proposal	The company is exploring the option of developing a management plan for the watershed of the Nimboyores River in order to ensure the protection of the water source in the long term. This water will be key for the development of the hotel's expansion projects.
B. Water Use Charges		
(i) Heredia Public Water Supply Company	Charges levied to water consumers, payments to forest owners pending	Company collects 1.90/m3 in 1999 to help protect the company's catchment areas (Ciruelas, Segundo, Bermudez, and Tibas rivers). Payments to landowners have not begun yet.

Source: CLUWRR, 2004 (adapted from Rojas and Aylward, forthcoming).

Results of Table 4.9, suggest that depending on the level of reduction in fertilizer use we want to get, the payments go from USD 75 per hectare to USD 375 per hectare. In this case, instead of valuing the environmental services of the cloud forest in the upper watershed, we are valuing the environmental disservices on the wetlands of Palo Verde.

Another consideration is the fact that this rice cultivation is made thanks to the Arenal-Tempisque Irrigation Project. Cloud forests on the upper Arenal-Tempisque watershed make this irrigation possible, which are another consideration that we are not taking into account in this analysis. In deciding, for example, a payment for environmental disservices cause for the use of agrochemicals, we are not including any payment for the environmental services provided by these cloud forests. Although we have been including irrigation payments in this study, these payments are basically for maintenance of the irrigation system and are not invested in direct environmental protection according with the information collected about it.

iv. Improve soil quality: Falconiana as a model

Under this scenario, the Costa Rican Government could design customized policies for different communities depending on biophysical conditions (for example soil quality). In this case, we are assuming that fertilizer consumption depends on biophysical factors and the targets on fertilizer reduction can be designed based on this information.

According with the results of the Crystal Ball simulation presented in this section, no differences could be found using the community dummy as a proxy for soil quality. Given these results, this policy scenario appears to be not feasible in this area.

4.5. Conclusions

Important conclusions can be made based on the results of this chapter. The estimation of the fertilizer demand function suggests that price of fertilizer and price of rice seeds are the variables that most affect the level of fertilizer demanded by farmers. The results also suggest that farmers of Falconiana tend to demand less fertilizer, perhaps due to better soil quality in this community. The estimated function explains 40% of the variation in the quantity of fertilizer demanded. More data are needed to test the effect of other input prices.

According to our estimates, the price elasticity of fertilizer demand is –0.456 and the cross price elasticities with respect to price of rice seeds is 1.908. With more variation in output price, unconditional factor demands could be estimated to determine the elasticity of fertilizer demand with respect to the price of rice.

Related with the level of profitability, it is clear with the results of this study that the level of profits is highly influenced by the application of a tariff on imported rice that elevates the domestic price. Considering a scenario without tariff, only close to 9% of the farmers in this area earn a profit comparable with the minimum salary defined for a household in Costa Rica. This should be taken into consideration by the local authorities if we consider that Costa Rica just signed a free trade agreement with the United States, the country that produces more than 90% of the imported rice.

According with the fertilizer demand function estimated in this study, the use of fertilizers has an important impact on rice yields for landowners where a 1% change in the use of fertilizer leads to a 2.64% change in output quantity.

Different policy scenarios seeking the reduction in fertilizer use were analyzed. The direct intervention on fertilizer price through the imposition of a tax had the greatest impact on fertilizer demand.

The forecast values of future fertilizer consumption provided evidence to conclude that the consumption of fertilizer will not suffer important changes, keeping its highly intensive use.

Future policies to reduce fertilizer consumption should consider two important elements, the impact of the fertilizer on rice yields in this particular region of Costa Rica and the environmental impact of its use on the wetlands of the Palo Verde National Park. These results can help to guide future research and will add important information for the formulation of future regulations related with the use of agrochemicals associated with the rice production around this park.

Another conclusion is related with the use of Monte Carlo simulation in this study and the functional forms used to predict profits and fertilizer demand. Given the logarithmic form of these two functions, the forecast results have to be considered with caution. For the case of profits, the logarithmic form rules out the possibility of estimating negative profits, and it constitutes an important limitation given the high profit variability in this region. For the case of fertilizer consumption, the minimum and maximum values obtained from the entire range of forecasted values have no practical meaning.

Finally, results suggest that the introduction of new varieties of rice seeds could help to improve the level of profitability and decrease the intensive use of fertilizer. The development of new seeds varieties that are more pest resistant and more productive is being pursued in many other countries that produce rice. Better seeds varieties with decreasing marginal response to fertilizer can promote less intensive use of these agrochemicals. However, clear information must be generated between quality of seeds, price and fertilizer requirement. The Costa Rican Rice Office could play a fundamental role, especially in the diffusion of information to farmers on the true fertilizer requirements of the different varieties and the introduction in Costa Rica of new varieties produced in other countries.

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APPENDICES

6. Appendices

6.1. Field questionnaire

Nombre Entrevistado: Comunidad: No. personas:

ACTIVIDADES AGROPECUARIAS COMO TRABAJO INDEPENDIENTE

PARTE A: DATOS DE LA UNIDAD DE PRODUCCION AGROPECUARIA

1. En este hogar, hay alguna persona que trabaje tierras prestadas u ocupadas por su cuenta o que tenga tierras agropecuarias ya sean propias, arrendadas o a medias? Si ( ) 1 No ( ) 2 **-------> Preg. 5**	2. Quién es la persona mejor informada sobre la actividad agropecuaria del hogar? ( ) CP Persona entrevistada ( ) CP	3. En los últimos 12 meses (desde…) trabajaron en tierras propias Si ( ) --> Cuantas parcelas? ( )**---->Preg. 6** No ( )	4. En los últimos 12 meses trabajaron en tierras arrendadas, tomadas a media o prestadas? Si ( )---> Cuantas parcelas? ( )**---->Preg. 12** No ( )	5. En los últimos 12 meses vendieron o compraron tierras destinadas a usos agropecuarios? Si ( )---> Cuantas parcelas? ( )**---->Preg. 17** No ( )**--->pase a seccion B**	

A.1 PARCELAS PROPIAS

Nº	6. Registre en cada fila el nombre de la parcela y el uso principal que tienen (incluya las tierras del patio que tienen siembras)	7. Cuál es la superficie de esta parcela? (Hectárea…1 Manzana…2 Metro cuadrado…3 Caballería…4 Cuerda…5)	8. Cuanta superficie tiene bajo riego?	9. En los últimos 12 meses cuánta tierra entregaron a terceros para que la trabajen? (no entregaron anote 00 y **pase a peg. 4**)	10. Cómo le pagan por esta tierra? dinero (1), cosecha (2), dinero y cosecha (3), Trabajo (4), no le pagan (5), otro (6, cual?)	11. Cuánto dinero recibió los últimos 12 meses por las tierras entregadas a terceros? (valorizar los pagos no monetarios)
Nº	Nombre	Superficie / Cod. S	Superficie / Cod. S	Superficie / Cod. S	Código	Colones
1						
2						
3						
4						

A.2 PARCELAS ALQUILADAS, PRESTADAS O A MEDIAS

Nº	12. Registre en cada fila el nombre de las parcelas, con las tierras con arriendo, usufructo o a medias	13. Cuál es la superficie de esta parcela?	14. Por trabajar en esta finca, usted paga en dinero (1 y **pase a preg. 16**), cosecha (2), cosecha y dinero (3), trabajo (4), no pagan (5), otro (6, cual?)?	15. Si tuvieran que pagar sólo en dinero por el uso de éstas tierras, cuánto pagarían al año?	16. Cuánto dinero pagan por el uso de la tierra y cada cuánto lo pagan? Períodos: cosecha…1 mes…2 tres meses…3 semestral…4 anual…5 otro, cuál?…6
Nº	Nombre	Superficie / Cod. S	Código	Colones	Colones / Período
1					
2					
3					
4					

A.3 PARCELAS VENDIDAS O COMPRADAS EN LOS ULTIMOS 12 MESES

		Vendidas			Compradas	
Nº	17. Registre en cada fila el nombre de las fincas vendidas o compradas por el hogar	18. Cuál es la superficie de ésta parcela que vendió?	19. En cuanto dinero la vendieron?	20. Lo que usted vendió fue un derecho de posesión? Si (1) No (2)	21. Cuál es la superficie de ésta parcela que compró?	22. En cuánto dinero la compraron?
Nº	Nombre	Superficie / Cod. S	Colones	Código	Superficie / Cod. S	Colones
1						
2						
3						
4						

PARTE B: ACTIVIDAD AGRICOLA										
23. En los últimos 12 meses (desde…), cosecharon algún producto agrícola sean granos básicos, frutales u otros? Si ( ) No ( )----->**Parte C**		24. Cuál fue la superficie cosechada de (…)?	25. Cuántas veces cosecharon (…) durante los últimos 12 meses?	26. Qué cantidad de (…) cosecharon durante los últimos 12 meses?	27. Qué cantidad de (…) vendieron durante los últimos 12 meses? No vendieron anotar 00 y **pasar a preg. 29**	28. En cuánto vendieron (…)?	29. Cuanto dinero recibio en total?	30. Qué cantidad de (…) tiene almacenado para la venta?	31. Qué cantidad de (…) destinó a otros usos?	32. Qué cantidad de (…) se perdió o se malogró?
Nº	Cultivo / Cod.	Superficie / Cod	Veces	Cantidad / Cod. Unidad	Cantidad/Cod. Unidad	Colones/Cod. Unidad	Colones	Cantidad/Unidad	Cantidad/Unidad	Cantidad/Unidad
1										
2										
3										
4										
5										
6										

PARTE C: INSUMOS								
33. En los últimos 12 meses (desde…) adquirieron (…)? Si ( ) 1 No ( ) 2**----> Preg. 35**			34. Cuánto le costó en total los (…) que compró en los últimos 12 meses?		35. Para qué cultivos compró o adquirió (…)?			
Nº	Insumo	Código	Cantidad	Precio (colones)	Cultivo/Código	Cultivo/Código	Cultivo/Código	Cultivo/Código
1	Granos o semillas							
2	Plantas							
3	Abonos orgánicos (gallinaza, compost, cáscara de arroz)							
4	Fertilizantes químicos (urea,compuestos, etc.)							
5	Funguicidas, pesticidas, insecticidas, herbicidas, etc.							
6	Empaques (sacos, bolsas, cajas, etc.)							

PARTE D: GASTOS EN ACTIVIDADES AGRICOLAS Y			
36. En los últimos 12 meses (desde…) gastó dinero en (…)? Si ( ) No ( )			37. Cuánto gastó en total?
Nº	Gastos	Código	Colones
1	Transporte y pago de fletes		
2	Almacenamiento y secado de productos		
3	Arriendo de maquinaria		
4	Mantención y reparación de maquinaria		
5	Arriendo de animales de trabajo		
6	Elaboración de subproductos		
7	Combustibles y lubricantes		
8	Impuestos sobre la tierra agrícola		
	Impuestos sobre venta de la producción		
9	Cuota riego		
10	Seguro		
11	Otros gastos, cuáles		

PARTE G: EQUIPO AGROPECUARIO, INSTALACIONES AGROPECUARIAS Y PRESTAMOS

G1. EQUIPOS AGROPECUARIOS

52. Tiene actualmente? Si ( ) 1 No ( ) 2----> **pasar a sección G2**			53. En total cuántos (...) tiene?	54. Cuantos anos tienen?	55. Cuánto le costo cada uno?	56. En cuánto podrían vender todos los (...) hoy en día?
Nº	Tipo de equipo agropecuario	Código	Cantidad	Cantidad	Cantidad	Colones
1	Implementos de tiro animal					
2	Tractor					
3	Implementos de tractor					
4	Cosechadora					
5	Sembradora					
6	Bomba de agua					
7	Camión, camioneta, jeep					
8	Animales de trabajo					
9	Bomba fumigadora					
10	Planta eléctrica					
11	Equipo de riego					
12	Pequeñas herramientas					
13	Ordeñadora					
14	Carreta de bueyes, carretón de caballo					
15	Otro, cuál?					
16	Otro, cuál?					
17	Otro, cuál?					

G.2 INSTALACIONES

57. Tienen ustedes en la actualidad? Si ( ) 1 No ( ) 2- **--> pasar a sección H**			58. En total cuántos (...) tienen?	59. Cuántos (...) compraron durante los últimos 12 meses?	60. En cuánto podrían vender todos los (...) hoy en día?
Nº	Tipo de instalación	Código	Cantidad	Cantidad	Colones
1	Cobertizo / galera				
2	Molinos				
3	Tanques				
4	Pozos				
5	Bañaderos				
6	Silos				
7	Secadores				
8	Bodega				
9	Corrales				
10	Otro, cuál?				
11	Otro, cuál?				

G.3 PRESTAMOS

61. En los ultimos 12 meses recibio algun prestamo para financiar los gastos de su actividad agricola y/o pecuaria? Si ( )----> cuantos? No ( )**--->pasar a seccion H**	62. De que instituciones o personas obtuvo el mayor prestamo?		63. Como les entregaron el prestamo? Efectivo...( ) Especie, insumo, materia prima...( ) Efectivo y especies...( )	64. De cuanto fue el prestamo?	65. Cuanto pago o pagara en total por este prestamo?	66. En que plazo lo pagara?	
	Banco privado			Colones	Colones	Plazo	Valor
	Banco estatal					Dias	
	Financieras					Meses	
	Tarjeta de credito		**Preguntas abiertas:**			Anos	
	Linea de credito						
	Cooperativa de ahorro y credito						
	Otras cooperativas						
	Asociacion de productores						
	Banco comunal						
	ONG / Proyectos						
	Casa de empeno						
	Prestamista particular						
	Amigos/parientes/vecinos						
	Otro, cual?						

Preguntas abiertas:

Que haria usted si el precio del cultivo sube, digamos en un 20% (7.500 pesos caso del arroz)?

Que hace usted cuando cambia el precio de los insumos (agroquimicos, mano de obra)?

Que otro factor determina que usted siga cultivando y cuales son los pricipales problemas que hay que enfrentar a lo largo del ciclo?

PARTE H: PRODUCTOS Y SUBPRODUCTOS DE ORIGEN AGRICOLA										
67. En los últimos 12 meses (desde…), elaboraron algún subproducto con su producción agrícola? Si ( ) 1 No ( ) 2 **--->pasar a sección I**			68. Qué cantidad de (…) obtienen en un mes?	69. En un mes, qué cantidad de (…) vendieron y en cuánto la vendieron?		70. En un mes, qué cantidad de (…) dejan para el consumo del hogar y cuánto vale esa cantidad?		71. En un mes, qué cantidad de (…) regalan o dedican al trueque y cuánto vale esa cantidad?	
Nº	Tipo de producto	Código	Cantidad / Unidad	Cantidad/unidad	Colones	Cantidad/unidad	Colones	Cantidad/unidad	Colones
1	Chicha, aguardiente								
2	Conservas								
3	Tortillas								
4	Mermelada, jaleas								
5	Otro, cuál?								
6	Otro, cuál?								
7	Otro, cuál?								

PARTE I: PRODUCCION FORESTAL					
72. En los últimos 12 meses (desde…), cortó o taló arboles para la venta o el consumo del hogar Si ( ) 1 No ( ) 2**---->Fin**	73. Qué tipo de árboles o plantas cortó o taló en los últimos 12 meses?		74. Cuál fue el valor total de los/las (…) que cortó en los últimos 12 meses?	75. Cuál fue el valor total de los/las (…) que vendió en los últimos 12 meses?	76. Cuál fue el valor total de los/las (…) que consumió en los últimos 12 meses?
	Arboles o plantas	Código	Colones	Colones	Colones

6.2. Bivariate correlation matrix[1]

	Seed[2]	Fertilizer[3]	Pesticides[4] Herbicides	Harvest[5] Transportation	Machinery[6]	Irrigation[7]	Family Size	Hired[8] Labor	Land	Land[9] Preparation	Soil[10] Quality	R-square
Seed	1.000	0.067	-0.137	0.167	0.168	-0.114	-0.019	0.137	0.067	0.253	0.009	0.216
Fertilizer		1.000	0.532	0.395	0.357	0.111	-0.015	0.009	0.255	0.063	-0.251	0.582*
Pesticides Herbicides			1.000	0.180	0.050	-0.081	0.154	0.221	0.054	-0.005	-0.317	0.427*
Harvest Transportation				1.000	0.753	0.308	0.153	0.211	0.039	0.325	-0.243	0.577*
Machinery					1.000	0.321	-0.063	0.194	0.120	0.388	-0.228	0.657*
Irrigation						1.000	-0.075	0.245	-0.064	0.138	0.224	0.279
Family Size							1.000	0.258	-0.239	-0.109	0.082	0.275
Hired Labor								1.000	-0.030	0.254	-0.092	0.400
Land									1.000	0.071	-0.170	0.249
Land Preparation										1.000	-0.239	0.310
Soil Quality											1.000	0.332

[1] Based on 40 households of Bagatzi, Falconiana and La Soga
[2] Physical quantities in quintals per hectare
[3] Physical quantities in quintal per hectare
[4] Cost in Colones per hectare
[5] Cost in Colones per hectare
[6] Cost in Colones per hectare
[7] Cost in Colones per hectare
[8] Cost in Colones per hectare
[9] Cost in Colones per hectare
[10] Community dummy used as a proxy for soil quality

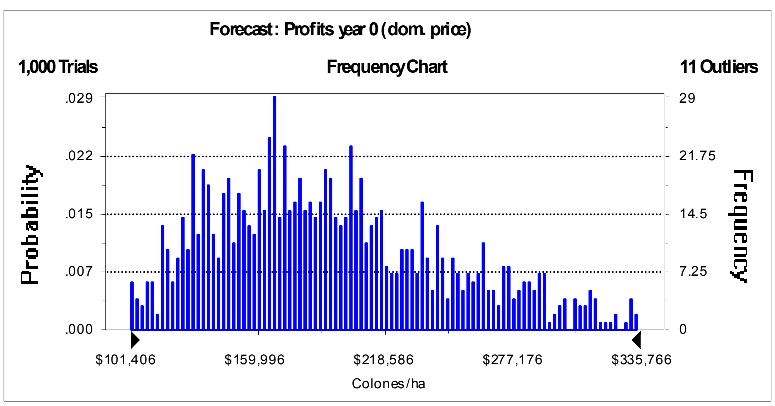
6.3. Crystal Ball reports

Crystal Ball
Report

Forecast: Profits year 0 (domestic price)

Summary:
Display Range is from $101,406 to $335,766 Colones/ha
Entire Range is from $101,406 to $352,933 Colones/ha
After 1,000 Trials, the Std. Error of the Mean is $1,712

Statistics:	Value
Trials	1000
Mean	$194,983
Median	$176,847
Mode	---
Standard Deviation	$54,147
Variance	$2,931,917,060
Skewness	0.62
Kurtosis	2.81
Coeff. of Variability	0.28
Range Minimum	$101,406
Range Maximum	$352,933
Range Width	$251,527
Mean Std. Error	$1,712.28



Forecast: Profits year 0 (domestic price) (cont'd)

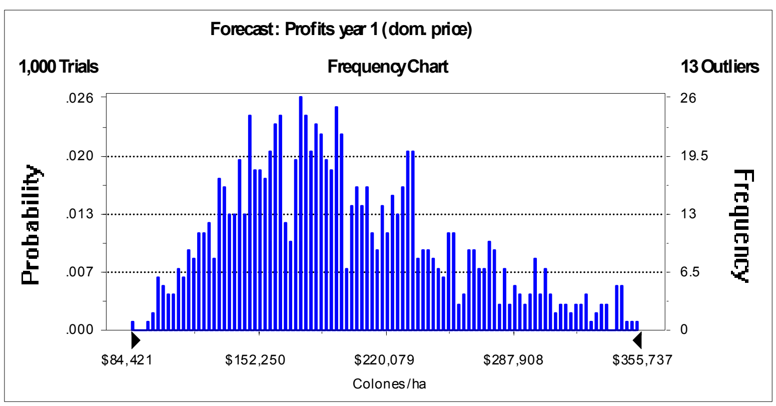
Percentile	Colones/ha
0%	$154,887
10%	$147,611
25%	$127,909
50%	$176,847
75%	$219,210
90%	$238,162
100%	$148,948

Forecast: Profits year 1 (domestic price)

Summary:

Display Range is from $84,421 to $355,737 Colones/ha
Entire Range is from $84,421 to $408,359 Colones/ha
After 1,000 Trials, the Std. Error of the Mean is $1,893

Statistics:	Value
Trials	1000
Mean	$200,091
Median	$195,875
Mode	---
Standard Deviation	$59,864
Variance	$3,583,694,159
Skewness	0.75
Kurtosis	3.26
Coeff. of Variability	0.30
Range Minimum	$84,421
Range Maximum	$408,359
Range Width	$323,938
Mean Std. Error	$1,893.06



Forecast: Profits year 1 (dom. price) (cont'd)

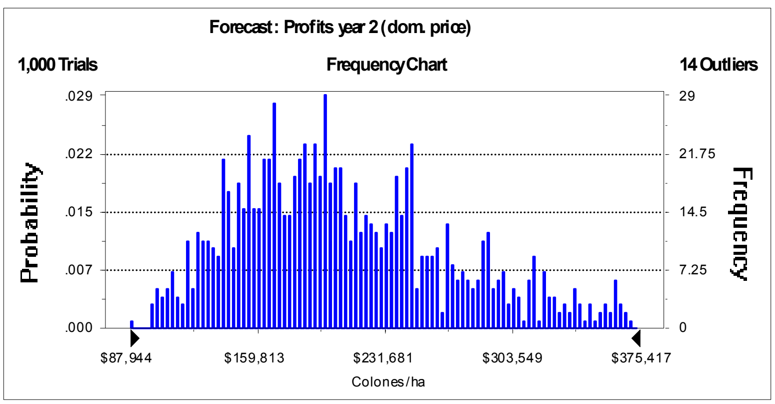
Percentile	Colones/ha
0%	$147,816
10%	$163,740
25%	$124,440
50%	$195,875
75%	$203,422
90%	$236,491
100%	$157,552

Forecast: Profits year 2 (domestic price)

Summary:

Display Range is from \$87,944 to \$375,417 Colones/ha
Entire Range is from \$87,944 to \$427,775 Colones/ha
After 1,000 Trials, the Std. Error of the Mean is \$1,998

Statistics:	Value
Trials	1000
Mean	\$211,120
Median	\$206,419
Mode	---
Standard Deviation	\$63,191
Variance	\$3,993,121,509
Skewness	0.74
Kurtosis	3.25
Coeff. of Variability	0.30
Range Minimum	\$87,944
Range Maximum	\$427,775
Range Width	\$339,831
Mean Std. Error	\$1,998.28



Forecast: Profits year 2 (dom. price) (cont'd)

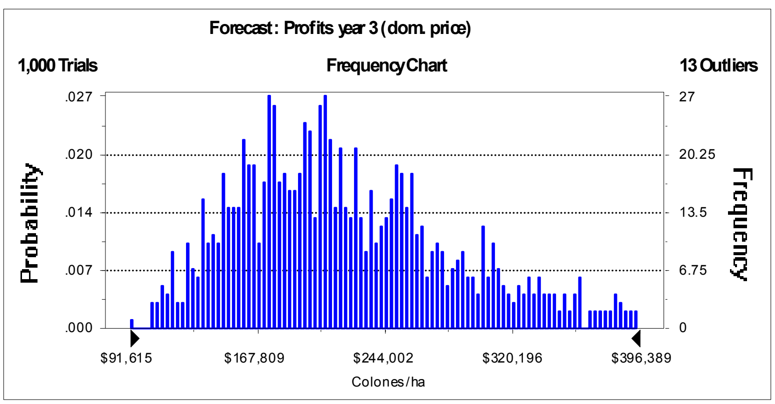
Percentile	Colones/ha
0%	\$156,346
10%	\$173,075
25%	\$132,244
50%	\$206,419
75%	\$214,219
90%	\$246,787
100%	\$163,005

Forecast: Profits year 3 (dom. price)

Summary:

Display Range is from $91,615 to $396,389 Colones/ha
Entire Range is from $91,615 to $448,115 Colones/ha
After 1,000 Trials, the Std. Error of the Mean is $2,112

Statistics:	Value
Trials	1000
Mean	$222,775
Median	$217,531
Mode	---
Standard Deviation	$66,775
Variance	$4,458,847,827
Skewness	0.74
Kurtosis	3.25
Coeff. of Variability	0.30
Range Minimum	$91,615
Range Maximum	$448,115
Range Width	$356,500
Mean Std. Error	$2,111.60



Forecast: Profits year 3 (dom. price) (cont'd)

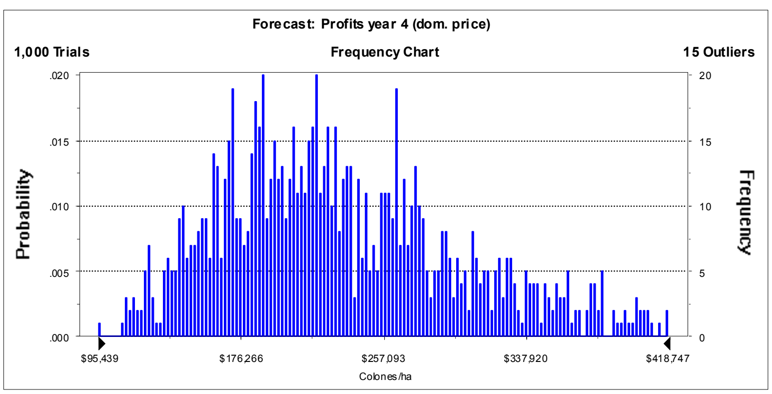
Percentile	Colones/ha
0%	$165,369
10%	$182,943
25%	$140,536
50%	$217,531
75%	$225,589
90%	$257,532
100%	$168,647

Forecast: Profits year 4 (domestic price)

Summary:

Display Range is from $95,439 to $418,747 Colones/ha
Entire Range is from $95,439 to $473,527 Colones/ha
After 1,000 Trials, the Std. Error of the Mean is $2,234

Statistics:	Value
Trials	1000
Mean	$235,093
Median	$229,241
Mode	---
Standard Deviation	$70,636
Variance	$4,989,465,773
Skewness	0.74
Kurtosis	3.25
Coeff. of Variability	0.30
Range Minimum	$95,439
Range Maximum	$473,527
Range Width	$378,088
Mean Std. Error	$2,233.71



Forecast: Profits year 4 (domestic price) (cont'd)

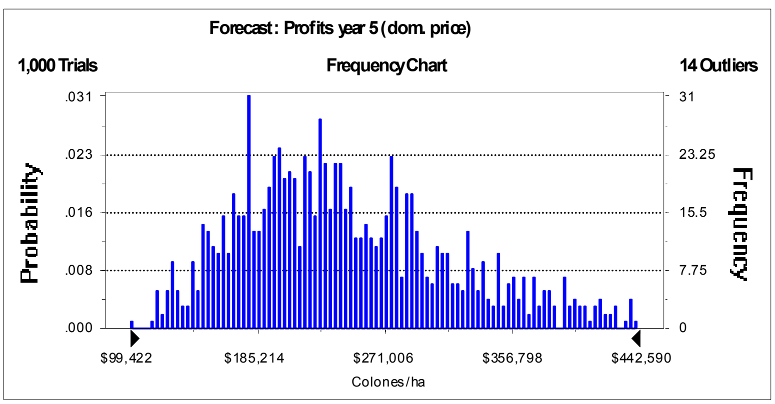
Percentile	Colones/ha
0%	$174,912
10%	$193,373
25%	$149,349
50%	$229,241
75%	$237,562
90%	$268,745
100%	$174,484

Forecast: Profits year 5 (domestic price)

Summary:

Display Range is from $99,422 to $442,590 Colones/ha
Entire Range is from $99,422 to $505,187 Colones/ha
After 1,000 Trials, the Std. Error of the Mean is $2,365

Statistics:	Value
Trials	1000
Mean	$248,112
Median	$241,582
Mode	---
Standard Deviation	$74,799
Variance	$5,594,932,188
Skewness	0.74
Kurtosis	3.26
Coeff. of Variability	0.30
Range Minimum	$99,422
Range Maximum	$505,187
Range Width	$405,765
Mean Std. Error	$2,365.36



Forecast: Profits year 5 (dom. price) (cont'd)

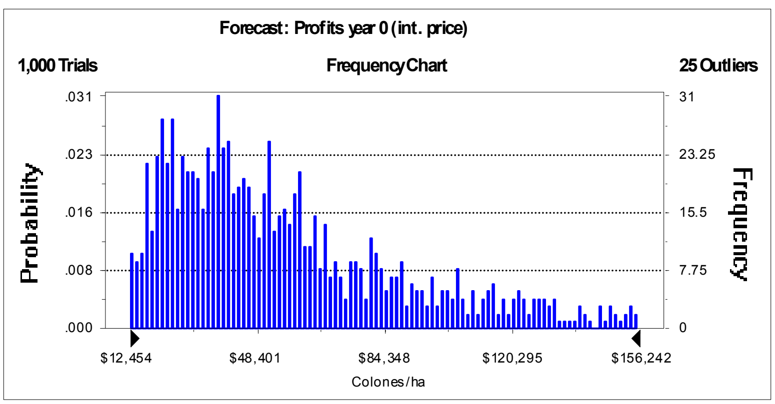
Percentile	Colones/ha
0%	$185,005
10%	$204,398
25%	$158,715
50%	$241,582
75%	$250,171
90%	$280,446
100%	$180,523

Forecast: Profits year 0 (international price)

Summary:

Display Range is from $12,454 to $156,242 Colones/ha
Entire Range is from $12,454 to $199,727 Colones/ha
After 1,000 Trials, the Std. Error of the Mean is $1,183

Statistics:	Value
Trials	1000
Mean	$58,998
Median	$42,926
Mode	---
Standard Deviation	$37,401
Variance	$1,398,852,692
Skewness	1.30
Kurtosis	4.42
Coeff. of Variability	0.63
Range Minimum	$12,454
Range Maximum	$199,727
Range Width	$187,273
Mean Std. Error	$1,182.73



Forecast: Profits year 0 (international price) (cont'd)

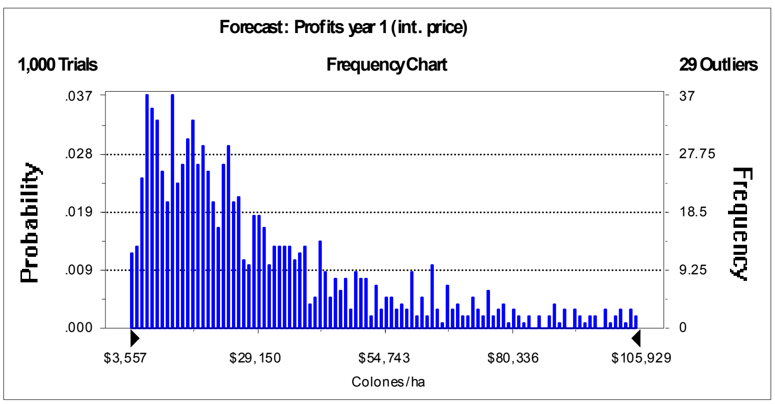
Percentile	Colones/ha
0%	$31,959
10%	$28,715
25%	$20,877
50%	$42,926
75%	$69,220
90%	$83,245
100%	$29,297

Forecast: Profits year 1 (international price)

Summary:

Display Range is from $3,557 to $105,929 Colones/ha
Entire Range is from $3,557 to $173,879 Colones/ha
After 1,000 Trials, the Std. Error of the Mean is $890

Statistics:	Value
Trials	1000
Mean	$32,787
Median	$22,368
Mode	---
Standard Deviation	$28,131
Variance	$791,371,410
Skewness	1.80
Kurtosis	6.55
Coeff. of Variability	0.86
Range Minimum	$3,557
Range Maximum	$173,879
Range Width	$170,322
Mean Std. Error	$889.59



Forecast: Profits year 1 (international price) (cont'd)

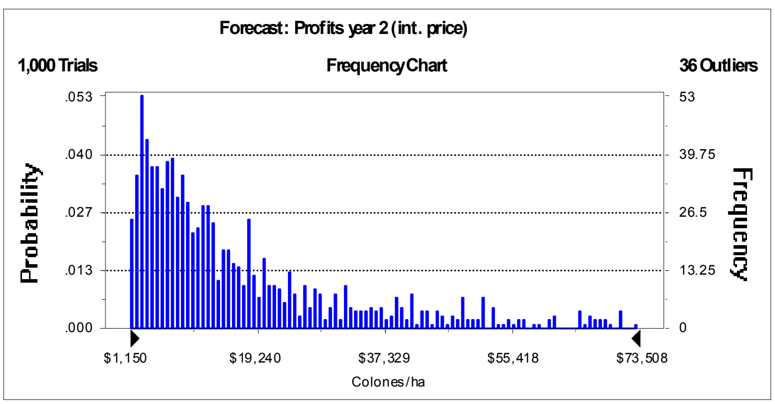
Percentile	Colones/ha
0%	$12,285
10%	$12,412
25%	$8,494
50%	$22,368
75%	$33,414
90%	$49,007
100%	$12,049

Forecast: Profits year 2 (international price)

Summary:

Display Range is from $1,150 to $73,508 Colones/ha
Entire Range is from $1,150 to $138,427 Colones/ha
After 1,000 Trials, the Std. Error of the Mean is $659

Statistics:	Value
Trials	1000
Mean	$19,363
Median	$11,089
Mode	---
Standard Deviation	$20,825
Variance	$433,685,714
Skewness	2.19
Kurtosis	8.56
Coeff. of Variability	1.08
Range Minimum	$1,150
Range Maximum	$138,427
Range Width	$137,277
Mean Std. Error	$658.55



Forecast: Profits year 2 (international price) (cont'd)

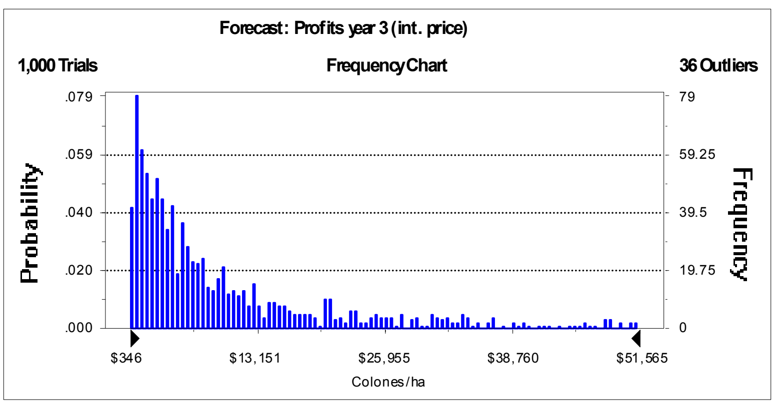
Percentile	Colones/ha
0%	$5,234
10%	$5,112
25%	$3,775
50%	$11,089
75%	$18,304
90%	$30,320
100%	$4,847

Forecast: Profits year 3 (international price)

Summary:

Display Range is from $346 to $51,565 Colones/ha
Entire Range is from $346 to $110,204 Colones/ha
After 1,000 Trials, the Std. Error of the Mean is $484

Statistics:	Value
Trials	1000
Mean	$11,772
Median	$5,498
Mode	---
Standard Deviation	$15,305
Variance	$234,235,971
Skewness	2.60
Kurtosis	11.11
Coeff. of Variability	1.30
Range Minimum	$346
Range Maximum	$110,204
Range Width	$109,858
Mean Std. Error	$483.98



Forecast: Profits year 3 (international price) (cont'd)

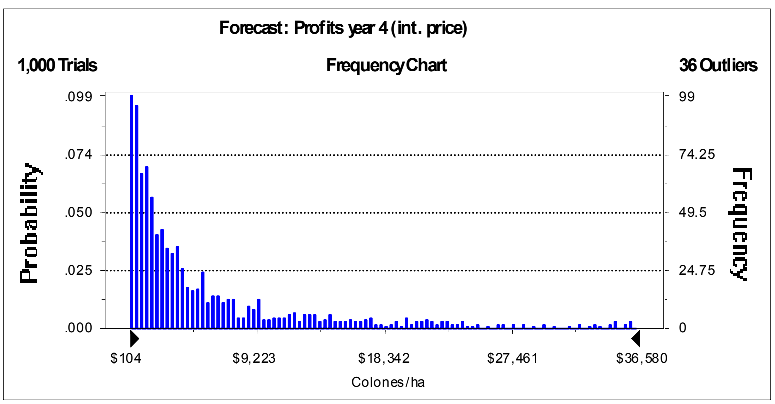
Percentile	Colones/ha
0%	$2,230
10%	$2,106
25%	$1,678
50%	$5,498
75%	$10,027
90%	$18,758
100%	$1,950

Forecast: Profits year 4 (international price)

Summary:

Display Range is from $104 to $36,580 Colones/ha
Entire Range is from $104 to $87,735 Colones/ha
After 1,000 Trials, the Std. Error of the Mean is $356

Statistics:	Value
Trials	1000
Mean	$7,346
Median	$2,726
Mode	---
Standard Deviation	$11,244
Variance	$126,423,441
Skewness	3.03
Kurtosis	14.21
Coeff. of Variability	1.53
Range Minimum	$104
Range Maximum	$87,735
Range Width	$87,631
Mean Std. Error	$355.56



Forecast: Profits year 4 (international price) (cont'd)

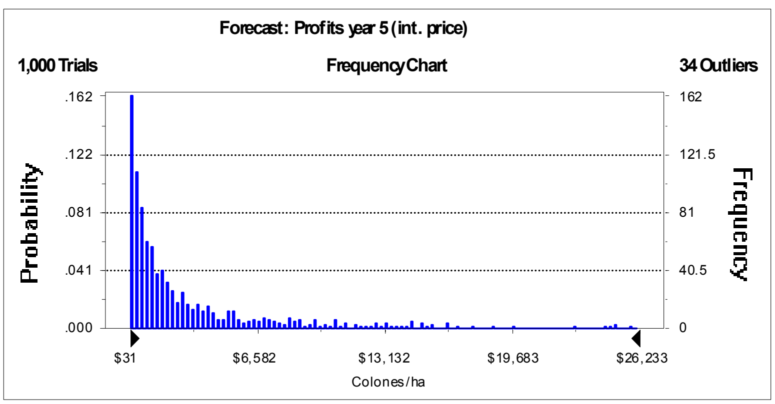
Percentile	Colones/ha
0%	$950
10%	$867
25%	$746
50%	$2,726
75%	$5,493
90%	$11,605
100%	$784

Forecast: Profits year 5 (international price)

Summary:

Display Range is from $31 to $26,233 Colones/ha
Entire Range is from $31 to $69,847 Colones/ha
After 1,000 Trials, the Std. Error of the Mean is $262

Statistics:	Value
Trials	1000
Mean	$4,690
Median	$1,351
Mode	---
Standard Deviation	$8,286
Variance	$68,655,710
Skewness	3.46
Kurtosis	17.88
Coeff. of Variability	1.77
Range Minimum	$31
Range Maximum	$69,847
Range Width	$69,816
Mean Std. Error	$262.02



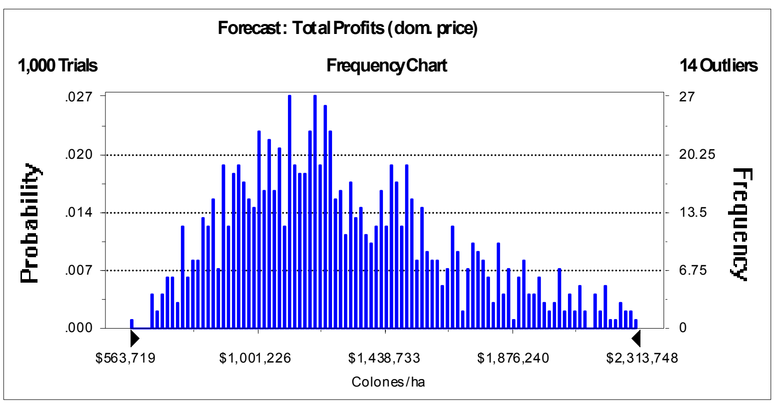
Forecast: Profits year 5 (international price) (cont'd)

Percentile	Colones/ha
0%	$405
10%	$357
25%	$331
50%	$1,351
75%	$3,009
90%	$7,180
100%	$316

Forecast: Total Profits (domestic price)

Summary:
Display Range is from $563,719 to $2,313,748 Colones/ha
Entire Range is from $563,719 to $2,595,476 Colones/ha
After 1,000 Trials, the Std. Error of the Mean is $12,182

Statistics:	Value
Trials	1000
Mean	$1,312,173
Median	$1,237,203
Mode	---
Standard Deviation	$385,221
Variance	1E+11
Skewness	0.73
Kurtosis	3.18
Coeff. of Variability	0.29
Range Minimum	$563,719
Range Maximum	$2,595,476
Range Width	$2,031,757
Mean Std. Error	$12,181.75



Forecast: Total Profits (domestic price) (cont'd)

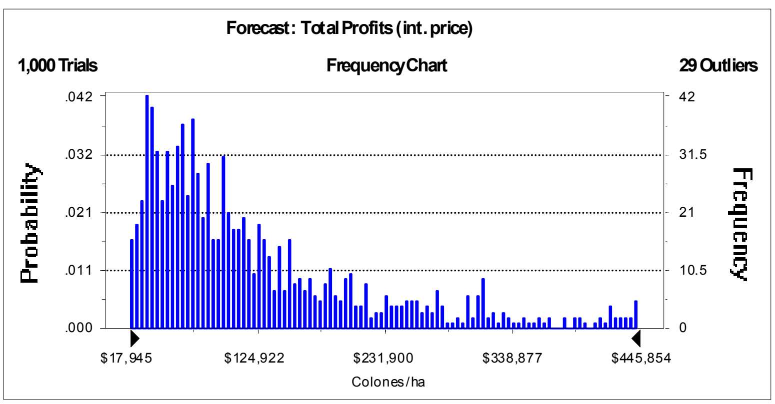
Percentile	Colones/ha
0%	$563,719
10%	$861,160
25%	$1,023,023
50%	$1,237,203
75%	$1,534,895
90%	$1,860,467
100%	$2,595,476

Forecast: Total Profits (international price)

Summary:

Display Range is from $17,945 to $445,854 Colones/ha
Entire Range is from $17,945 to $776,225 Colones/ha
After 1,000 Trials, the Std. Error of the Mean is $3,781

Statistics:	Value
Trials	1000
Mean	$134,956
Median	$95,280
Mode	---
Standard Deviation	$119,576
Variance	$14,298,446,975
Skewness	2.00
Kurtosis	7.58
Coeff. of Variability	0.89
Range Minimum	$17,945
Range Maximum	$776,225
Range Width	$758,280
Mean Std. Error	$3,781.33



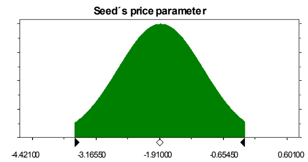
Forecast: Total Profits (international price) (cont'd)

Percentile	Colones/ha
0%	$17,945
10%	$34,794
25%	$55,756
50%	$95,280
75%	$168,915
90%	$301,593
100%	$776,225

<u>**Assumptions**</u>

Assumption: Seeds price parameter

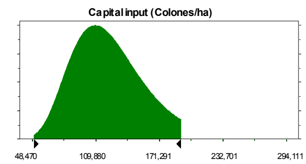
Normal distribution with parameters:
Mean -1.91000
Standard Dev. 0.83700



Selected range is from -3.58400 to -0.23600

Assumption: Capital input (Colones/ha)

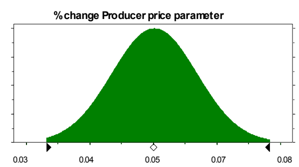
Lognormal distribution with parameters:
Mean 124,911
Standard Dev. 38,400



Selected range is from 49,840 to 191,970

Assumption: % change Producer price parameter

Normal distribution with parameters:
Mean 0.05
Standard Dev. 0.01

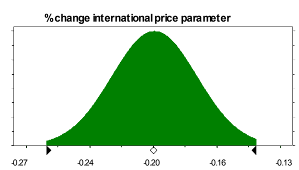


Selected range is from 0.03 to 0.08

Correlated with:
% change international price parameter (B12) 0.43

Assumption: % change international price parameter

Normal distribution with parameters:
Mean -0.20
Standard Dev. 0.02



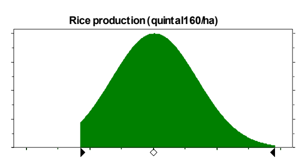
Selected range is from -0.26 to -0.14

Assumption: % change international price parameter (cont'd)

% change Producer price parameter (B9) 0.43

Assumption: Rice production (quintal160/ha)

Normal distribution with parameters:
Mean 60.2
Standard Dev. 18.1



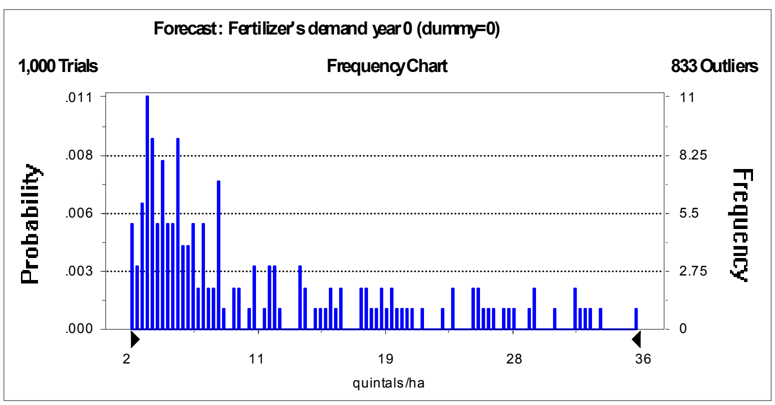
Selected range is from 29.2 to 111.9

Crystal Ball Report

Forecast: Fertilizer demand year 0 (dummy=0)

Summary:
Display Range is from 2 to 36 quintals/ha
Entire Range is from 0 to 6,790,617,658 quintals/ha
After 1,000 Trials, the Std. Error of the Mean is 7,961,938

Statistics:	Value
Trials	1000
Mean	15,312,448
Median	0
Mode	---
Standard Deviation	251,778,576
Variance	6E+16
Skewness	23.00
Kurtosis	574.66
Coeff. of Variability	16.44
Range Minimum	0
Range Maximum	6,790,617,658
Range Width	6,790,617,658
Mean Std. Error	7,961,937.67



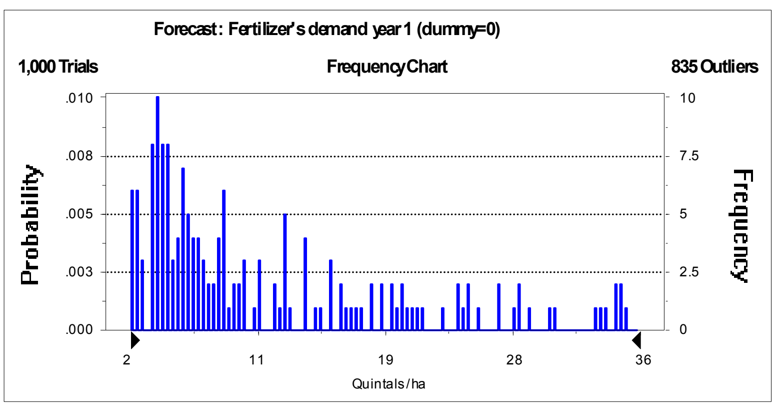
Forecast: Fertilizer demand year 0 (dummy=0) (cont'd)

Percentile	quintals/ha
0%	0
10%	12
25%	0
50%	0
75%	73,052
90%	6
100%	0

Forecast: Fertilizer demand year 1 (dummy=0)

Summary:
Display Range is from 2 to 36 Quintals/ha
Entire Range is from 0 to 9,567,753,502 Quintals/ha
After 1,000 Trials, the Std. Error of the Mean is 10,720,813

Statistics:	Value
Trials	1000
Mean	19,955,349
Median	0
Mode	---
Standard Deviation	339,021,889
Variance	1E+17
Skewness	24.46
Kurtosis	654.06
Coeff. of Variability	16.99
Range Minimum	0
Range Maximum	9,567,753,502
Range Width	9,567,753,502
Mean Std. Error	10,720,813.46



Forecast: Fertilizer demand year 1 (dummy=0) (cont'd)

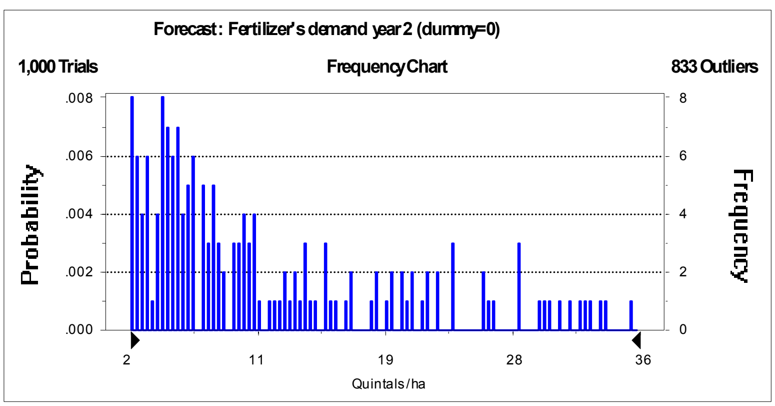
Percentile	Quintals/ha
0%	0
10%	14
25%	0
50%	0
75%	103,118
90%	5
100%	0

Forecast: Fertilizer demand year 2 (dummy=0)

Summary:

Display Range is from 2 to 36 Quintals/ha
Entire Range is from 0 to 11,777,781,351 Quintals/ha
After 1,000 Trials, the Std. Error of the Mean is 13,025,669

Statistics:	Value
Trials	1000
Mean	23,874,660
Median	0
Mode	---
Standard Deviation	411,907,818
Variance	2E+17
Skewness	25.02
Kurtosis	682.71
Coeff. of Variability	17.25
Range Minimum	0
Range Maximum	11,777,781,351
Range Width	11,777,781,351
Mean Std. Error	13,025,668.91



Forecast: Fertilizer demand year 2 (dummy=0) (cont'd)

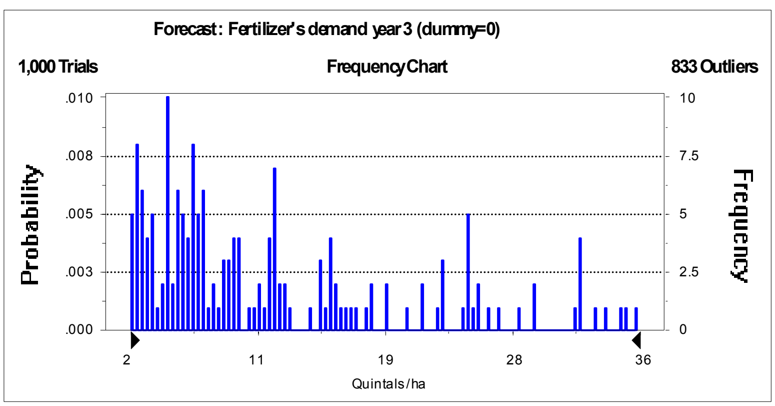
Percentile	Quintals/ha
0%	0
10%	16
25%	0
50%	0
75%	124,461
90%	6
100%	0

Forecast: Fertilizer demand year 3 (dummy=0)

Summary:

Display Range is from 2 to 36 Quintals/ha
Entire Range is from 0 to 14,498,297,174 Quintals/ha
After 1,000 Trials, the Std. Error of the Mean is 15,850,036

Statistics:	Value
Trials	1000
Mean	28,606,613
Median	0
Mode	---
Standard Deviation	501,222,132
Variance	3E+17
Skewness	25.55
Kurtosis	710.00
Coeff. of Variability	17.52
Range Minimum	0
Range Maximum	14,498,297,174
Range Width	14,498,297,174
Mean Std. Error	15,850,035.52



Forecast: Fertilizer demand year 3 (dummy=0) (cont'd)

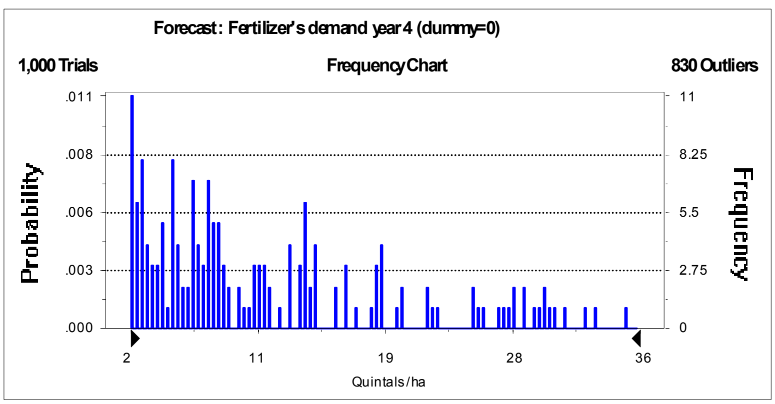
Percentile	Quintals/ha
0%	0
10%	18
25%	0
50%	0
75%	150,222
90%	7
100%	0

Forecast: Fertilizer demand year 4 (dummy=0)

Summary:

Display Range is from 2 to 36 Quintals/ha
Entire Range is from 0 to 17,847,217,119 Quintals/ha
After 1,000 Trials, the Std. Error of the Mean is 19,313,556

Statistics:	Value
Trials	1000
Mean	34,327,817
Median	0
Mode	---
Standard Deviation	610,748,272
Variance	4E+17
Skewness	26.05
Kurtosis	735.61
Coeff. of Variability	17.79
Range Minimum	0
Range Maximum	17,847,217,119
Range Width	17,847,217,119
Mean Std. Error	19,313,556.18



Forecast: Fertilizer demand year 4 (dummy=0) (cont'd)

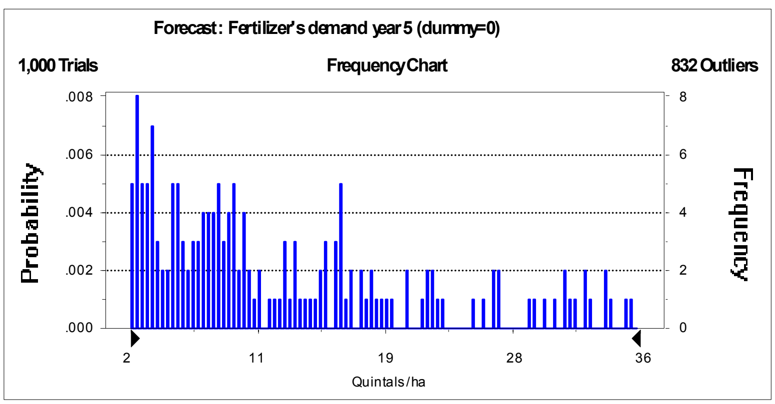
Percentile	Quintals/ha
0%	0
10%	20
25%	0
50%	0
75%	181,315
90%	8
100%	0

Forecast: Fertilizer demand year 5 (dummy=0)

Summary:

Display Range is from 2 to 36 Quintals/ha
Entire Range is from 0 to 21,969,694,445 Quintals/ha
After 1,000 Trials, the Std. Error of the Mean is 23,563,671

Statistics:	Value
Trials	1000
Mean	41,254,848
Median	0
Mode	---
Standard Deviation	745,148,688
Variance	6E+17
Skewness	26.52
Kurtosis	759.33
Coeff. of Variability	18.06
Range Minimum	0
Range Maximum	21,969,694,445
Range Width	21,969,694,445
Mean Std. Error	23,563,670.51



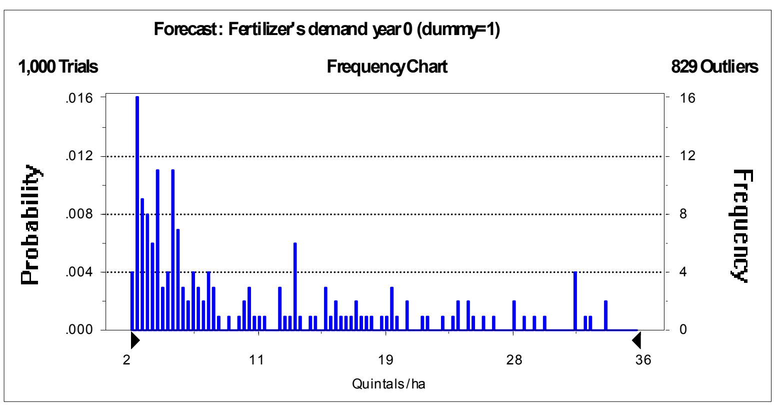
Forecast: Fertilizer demand year 5 (dummy=0) (cont'd)

Percentile	Quintals/ha
0%	0
10%	23
25%	0
50%	0
75%	218,844
90%	9
100%	0

Forecast: Fertilizer demand year 0 (dummy=1)

Summary:
Display Range is from 2 to 36 Quintals/ha
Entire Range is from 0 to 4,049,803,420 Quintals/ha
After 1,000 Trials, the Std. Error of the Mean is 5,129,733

Statistics:	Value
Trials	1000
Mean	10,510,585
Median	0
Mode	---
Standard Deviation	162,216,409
Variance	3E+16
Skewness	21.18
Kurtosis	481.76
Coeff. of Variability	15.43
Range Minimum	0
Range Maximum	4,049,803,420
Range Width	4,049,803,420
Mean Std. Error	5,129,733.26



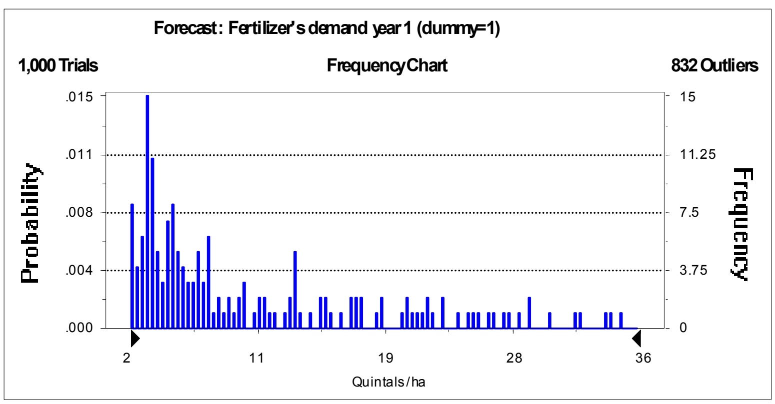
Forecast: Fertilizer demand year 0 (dummy=1) (cont'd)

Percentile	Quintals/ha
0%	0
10%	10
25%	0
50%	0
75%	60,810
90%	5
100%	0

Forecast: Fertilizer demand year 1 (dummy=1)

Summary:
Display Range is from 2 to 36 Quintals/ha
Entire Range is from 0 to 5,706,037,772 Quintals/ha
After 1,000 Trials, the Std. Error of the Mean is 6,779,511

Statistics:	Value
Trials	1000
Mean	13,584,203
Median	0
Mode	---
Standard Deviation	214,386,975
Variance	5E+16
Skewness	22.39
Kurtosis	549.09
Coeff. of Variability	15.78
Range Minimum	0
Range Maximum	5,706,037,772
Range Width	5,706,037,772
Mean Std. Error	6,779,511.41



Forecast: Fertilizer demand year 1 (dummy=1) (cont'd)

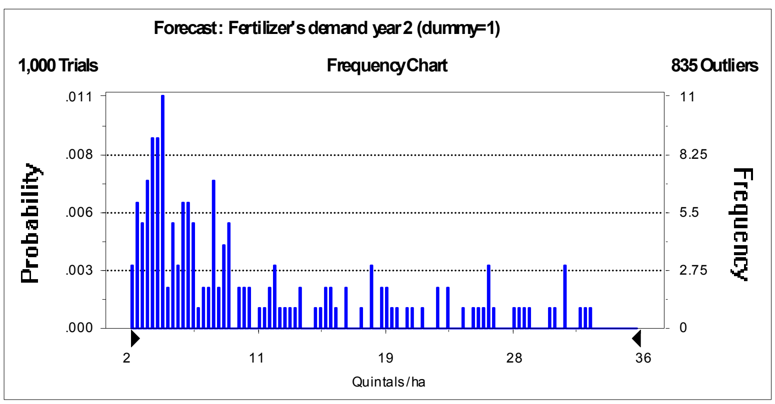
Percentile	Quintals/ha
0%	0
10%	11
25%	0
50%	0
75%	85,837
90%	4
100%	0

Forecast: Fertilizer demand year 2 (dummy=1)

Summary:

Display Range is from 2 to 36 Quintals/ha
Entire Range is from 0 to 7,024,059,018 Quintals/ha
After 1,000 Trials, the Std. Error of the Mean is 8,190,391

Statistics:	Value
Trials	1000
Mean	16,204,559
Median	0
Mode	---
Standard Deviation	259,002,908
Variance	7E+16
Skewness	22.94
Kurtosis	577.90
Coeff. of Variability	15.98
Range Minimum	0
Range Maximum	7,024,059,018
Range Width	7,024,059,018
Mean Std. Error	8,190,391.09



Forecast: Fertilizer demand year 2 (dummy=1) (cont'd)

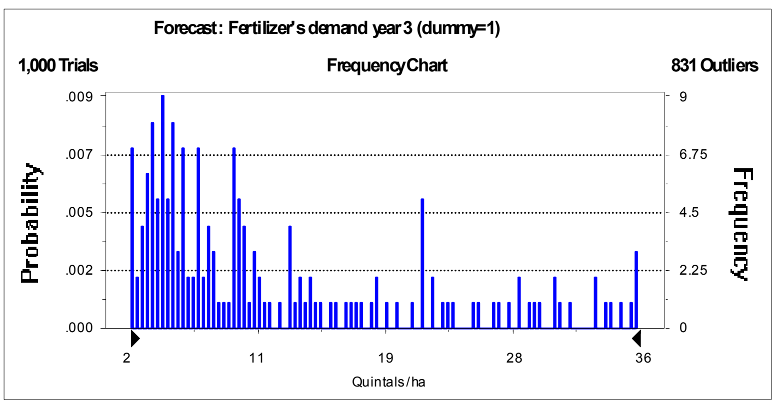
Percentile	Quintals/ha
0%	0
10%	12
25%	0
50%	0
75%	103,604
90%	4
100%	0

Forecast: Fertilizer demand year 3 (dummy=1)

Summary:

Display Range is from 2 to 36 Quintals/ha
Entire Range is from 0 to 8,646,526,198 Quintals/ha
After 1,000 Trials, the Std. Error of the Mean is 9,914,787

Statistics:	Value
Trials	1000
Mean	19,361,349
Median	0
Mode	---
Standard Deviation	313,533,097
Variance	1E+17
Skewness	23.49
Kurtosis	606.81
Coeff. of Variability	16.19
Range Minimum	0
Range Maximum	8,646,526,198
Range Width	8,646,526,198
Mean Std. Error	9,914,787.07



Forecast: Fertilizer demand year 3 (dummy=1) (cont'd)

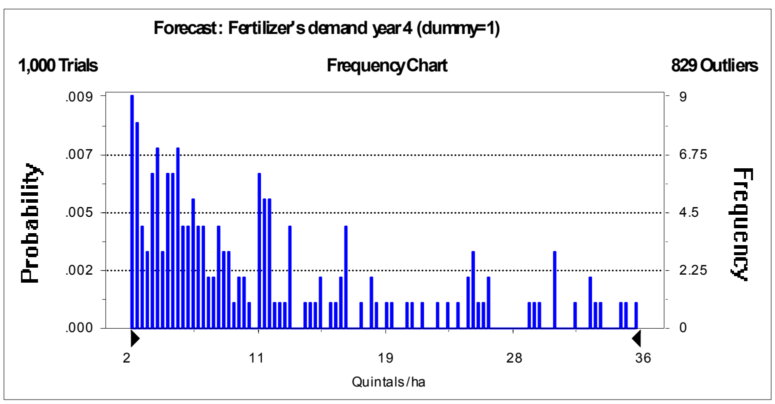
Percentile	Quintals/ha
0%	0
10%	14
25%	0
50%	0
75%	125,048
90%	5
100%	0

Forecast: Fertilizer demand year 4 (dummy=1)

Summary:

Display Range is from 2 to 36 Quintals/ha
Entire Range is from 0 to 10,643,762,404 Quintals/ha
After 1,000 Trials, the Std. Error of the Mean is 12,024,826

Statistics:	Value
Trials	1000
Mean	23,170,428
Median	0
Mode	---
Standard Deviation	380,258,380
Variance	1E+17
Skewness	24.04
Kurtosis	635.20
Coeff. of Variability	16.41
Range Minimum	0
Range Maximum	10,643,762,404
Range Width	10,643,762,404
Mean Std. Error	12,024,825.80



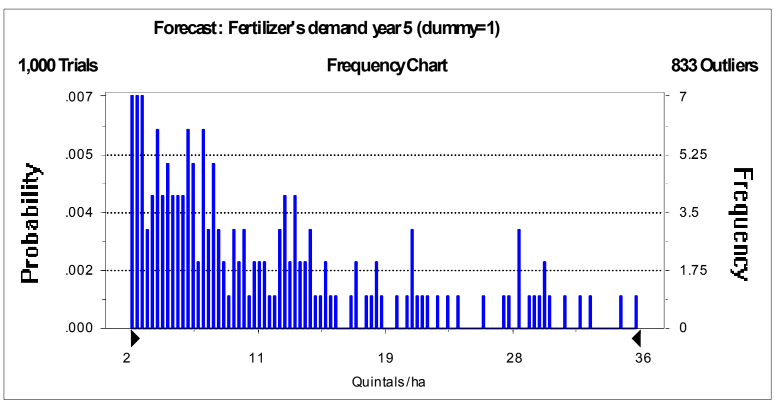
Forecast: Fertilizer demand year 4 (dummy=1) (cont'd)

Percentile	Quintals/ha
0%	0
10%	16
25%	0
50%	0
75%	150,931
90%	6
100%	0

Forecast: Fertilizer demand year 5 (dummy=1)

Summary:
Display Range is from 2 to 36 Quintals/ha
Entire Range is from 0 to 13,102,334,453 Quintals/ha
After 1,000 Trials, the Std. Error of the Mean is 14,609,485

Statistics:	Value
Trials	1000
Mean	27,773,885
Median	0
Mode	---
Standard Deviation	461,992,496
Variance	2E+17
Skewness	24.56
Kurtosis	662.52
Coeff. of Variability	16.63
Range Minimum	0
Range Maximum	13,102,334,453
Range Width	13,102,334,453
Mean Std. Error	14,609,485.48



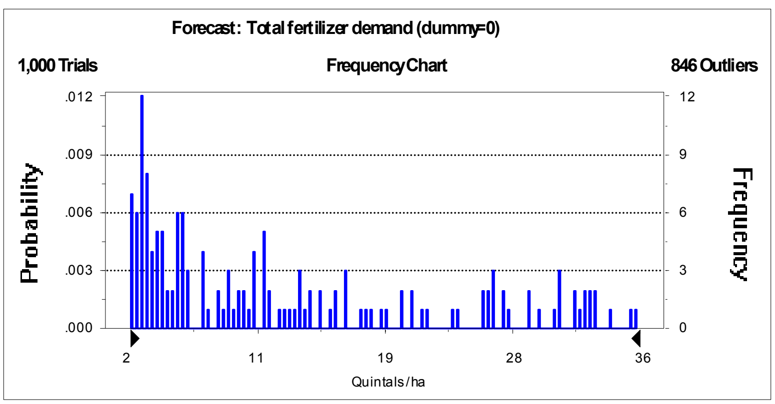
Forecast: Fertilizer demand year 5 (dummy=1) (cont'd)

Percentile	Quintals/ha
0%	0
10%	18
25%	0
50%	0
75%	182,171
90%	7
100%	0

Forecast: Total fertilizer demand (dummy=0)

Summary:
Display Range is from 2 to 36 Quintals/ha
Entire Range is from 0 to 82,451,361,248 Quintals/ha
After 1,000 Trials, the Std. Error of the Mean is 90,299,124

Statistics:	Value
Trials	1000
Mean	163,331,736
Median	64
Mode	---
Standard Deviation	2,855,509,040
Variance	8E+18
Skewness	25.47
Kurtosis	705.81
Coeff. of Variability	17.48
Range Minimum	0
Range Maximum	82,451,361,248
Range Width	82,451,361,248
Mean Std. Error	90,299,124.46



Forecast: Total fertilizer demand (dummy=0) (cont'd)

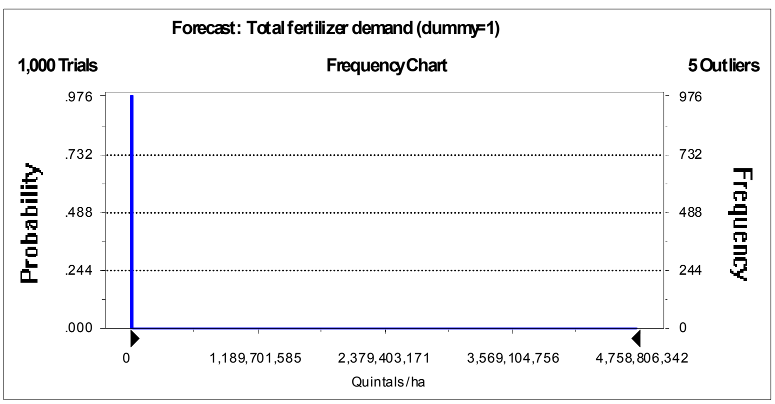
Percentile	Quintals/ha
0%	0
10%	0
25%	1
50%	64
75%	8,026
90%	672,558
100%	82,451,361,248

Forecast: Total fertilizer demand (dummy=1)

Summary:

Display Range is from 0 to 4,758,806,342 Quintals/ha
Entire Range is from 0 to 49,172,523,265 Quintals/ha
After 1,000 Trials, the Std. Error of the Mean is 56,534,243

Statistics:	Value
Trials	1000
Mean	110,605,009
Median	0
Mode	---
Standard Deviation	1,787,769,743
Variance	3E+18
Skewness	23.41
Kurtosis	602.30
Coeff. of Variability	16.16
Range Minimum	0
Range Maximum	49,172,523,265
Range Width	49,172,523,265
Mean Std. Error	56,534,243.21



Forecast: Total fertilizer demand (dummy=1) (cont'd)

Percentile	Quintals/ha
0%	1
10%	82
25%	0
50%	0
75%	708,402
90%	30
100%	0

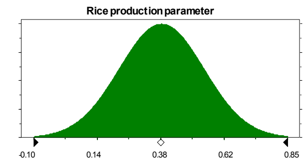
<u>**Assumptions**</u>

Assumption: Rice production parameter

Normal distribution with parameters:

Mean	0.38
Standard Dev.	0.16

Selected range is from -0.10 to 0.86

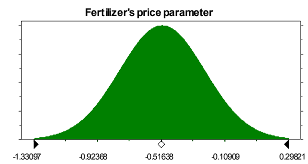


Assumption: Fertilizer price parameter

Normal distribution with parameters:

Mean	-0.51638
Standard Dev.	0.27153

Selected range is from -1.33100 to 0.29820

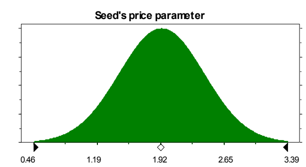


Assumption: Seeds price parameter

Normal distribution with parameters:

Mean	1.92
Standard Dev.	0.49

Selected range is from 0.45 to 3.39

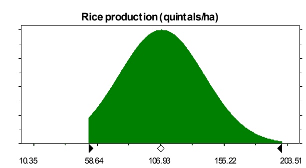


Assumption: Rice production (quintals/ha)

Normal distribution with parameters:

Mean	106.93
Standard Dev.	32.19

Selected range is from 52.00 to 199.00

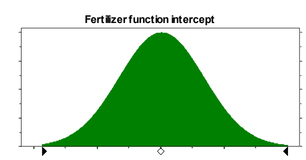


Assumption: Fertilizer function intercept

Normal distribution with parameters:

Mean	-12.67927
Standard Dev.	4.88549

Selected range is from -26.34570 to 1.97720

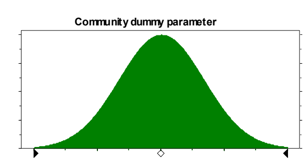


Assumption: Community dummy parameter

Normal distribution with parameters:

Mean	-0.24
Standard Dev.	0.12

Selected range is from -0.60 to 0.12

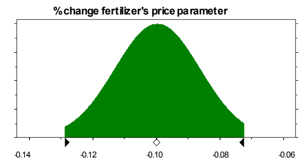


Assumption: % change fertilizer price parameter

Normal distribution with parameters:

Mean	-0.10
Standard Dev.	0.01

Selected range is from -0.13 to -0.07



Assumption: % change seeds price parameter

Normal distribution with parameters:

Mean	0.05
Standard Dev.	0.01

Selected range is from 0.02 to 0.08