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RISK, INSTITUTIONAL CHANGE AND TECHNOLOGY ADOPTION FOR LOW INCOME FARMERS: AN ANALYSIS OF NEW BEAN ALTERNATIVES FOR THE SOUTHERN LUILA REGION OF COLOMBIA, SOUTH AMERICA

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In Partial Fulfillment

of the Requirements for the Degree

Doctor of Philosophy

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by

Gustavo Arcia

Stanley R. Johnson Dissertation Supervisor

December 1980

To my wife Emilia and our daughter, Adriana, for their love and patience.

The undersigned, appointed by the Dean of the Graduate Faculty, have examined a thesis entitled

RISK, INSTITUTIONAL CHANGE AND TECHNOLOGY ADOPTION
FOR LOW INCOME FARMERS: AN ANALYSIS OF NEW BEAN
ALTERNATIVES FOR THE SOUTHERN HUILA REGION
OF COLOMBIA, SOUTH AMERICA

presented by Gustavo Arcia

a candidate for the degree of Doctor of Philosophy

and hereby certify that in their opinion it is worthy of acceptance.

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ABSTRACT

Economic development policies recently have placed increased interest on efforts to find solutions to food and population problems for low income countries. A natural area of focus for these policies has been the low income farms where birth rates are high and the economic circumstances in which the families find themselves are substandard. This low income farm problem has been approached by development of technologies to improve output levels for crops which are desirable from the point of view of home consumption and income producing potential. The present analysis considers a technology adoption problem for the Southern Huila region in Colombia. Characteristics of the new technology, attitudes toward risk, the institutional setting for farmers, and quality of information on new technology and prices are examined as factors influencing adoption.

Information on the new technology was developed from surveys by the CIAT Bean Team in Southern Huila. These surveys generated input-output coefficients for on-farm trials as well as information on the characteristics of households and farm units. Additional primary information was collected from a survey to determine attitudes toward risk

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and perceptions of uncertainty. For the former, risk aversion coefficients consistent with those indicated in the recent literature were estimated. Low income farmers were found to be relatively risk averse. For the latter, substantial discrepancies were discovered between perceptions of researchers on one hand and the farmers on the other related to the uncertainty associated with yields and prices of beans and other crops. The instrument used to elicit this information was novel and appears to have substantial potential as a mechanism for better directing extension information programs and, as well, understanding attitudes toward adoption of new technology by low income farmers.

The major hypothesis of the study related to the relative importance of institutional factors as compared to characteristics of new technologies for influencing adoption. The development of new technologies for low income farms is a process which requires time and substantial resources. At the same time, there may be institutions affecting farmers which can be altered with low political and economic costs. Two of these for the Southern Huila farmers related to bean price stabilization and improvement. On-farm storage options and marketing organizations were examined for their potential for altering characteristics of prices received by farmers adopting the new bean technology. Results indicated that the institutional factors could be altered so that risk averse farmers would find the existing new technology attractive for adoption.

The general conclusion from the research is that the adoption problem is more broad than traditionally perceived. New technologies shou be developed incorporating available information about farming systems and the circumstances in which the farmer or farming system is

operating. Many times, alterations in these factors, traditionally avoided because of political sensitivity, can be as important in improving the economic lot of low income farmers as the development and distribution of new technologies. A second conclusion concerns how the individual farmers are studied. The referenced gambling instruments employed in eliciting risk attitudes and perceptions of uncertainty would appear to have important potential for better directing efforts at improving the adoption of the new technologies and identifying problems associated with low adoption rates for technologies which on the surface appear to be attractive for low income farmers.

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CHAPTER I

INTRODUCTION

A General Perspective

During the past decade, economic development policy has undergone substantial change in effort to find the solution to the food and population problems in low income countries. These changes have been in response to sharp criticism based on the past performance of policy ideas largely exported from more developed economies. In general, these approaches have emphasized the industrial sector at the expense of agriculture and the rural populations.

Economic policies conducive to the attainment of a higher degree of industrialization and import substitution traditionally have been advanced as the path to economic betterment. Accordingly, there has been a tendency to relegate the farm sector to a support role in the development process in favor of a still pubescent industrial sector. It is difficult to ignore, however, that the majority of the populations in the developing areas reside in and depend on the agricultural sector. There is an intrinsic bind between the farm sectors of these countries and their economic development (Chenery [1960], Chenery and Taylor [1968], Mellor [1966, 1969]).

Progress in agriculture for the developing counties has been significant. But it has been confined largely to a small group within the rural society. This group has adopted modern, scale efficient

technology characterized by high levels of capital use and the cultivation of crops more suitable for export than for internal consumption. Unfortunately, this technological progress has not affected the great majority of the rural population employed in the traditional subsector of agriculture in a stagnated economic environment. The substantial efforts that have been made to help the stagnant subsector through generation of technology for small farm units have generally failed.

Reasons for this failure are many and varied. However, they all can be addressed within the framework of technology transfer, or the lack of it. Failure to transfer new farm technologies to the traditional farm subsector may have resulted due to inadequacies in the technologies, the transfer process or both. It appears then that to assimilate peasant farming into the mainstream of modern agriculture, still more effort should be focused on generating appropriate technologies and developing a more adequate transfer process. Scale neutral technologies have been promoted, i.e., new varieties, but the response from the small farm subsector has been poor. Are the farmers to blame? Or, perhaps the circumstances in which they operate and the new technologies themselves may not have been conducive to a widespread adoption (Falcon [1970], Schuh [1968], Wade [1974a, 1974b].

It is now increasingly recognized risk averse behavior may affect adoption rates. Recent research has shown risk attitudes to be an important factor in the decision making process for farmers. Furthermore, it appears that the individuals involved in development and adaptation programs for new technologies have not sufficiently taken this behavior into consideration. The untested nature of new

technologies in the small farm framework suggests that peasant farmers have been reluctant to incur uncertainties associated with adoption. That is, they have been unwilling to jeopardize their incomes for the potential gains available from new technologies.

Approaches to the solution of the problem of technology transfer have taken two main thrusts (Brown [1970], Evenson and Kislev [1975]). The first has involved the development of more appropriate farm technologies. Factors examined have included better varieties and site specific, small farm scale agronomic practices. This approach, while having generated some evidence of effectiveness, has taken great amounts of time and expense, requiring biological and phenological changes without the guarantee of successful adoption. The second approach has involved the modification of the institutional infrastructure to induce technology transfer and adoption. These modifications can be tailored to reduce the risks associated with the new technology and otherwise enhance their attractiveness. The second institutional approach offers the possibility of more rapid technology adoption, although at a cost in terms of political attractiveness. But the former approach, when successful, has not proved economically and politically inert in any case.

Design and Adoption of Small Farm Technology

Designing an adequate technology for the small farm has turned out to be more complex than originally believed. Partly due to an incomplete knowledge of the peasant economic and biophysical environment, many technological packages envisioned as the answer to the poverty of peasant farmers have gone mostly unnoticed by the intended

clientele. Before the network of International Research Centers came into existence there were few attempts to merge agronomic and economic research in an organized manner. As a consequence of the rapid development of new technologies in the international center network and unfortunate experiences regarding adoption, there arose the need to focus the research efforts more efficiently. Small farms became small farm systems and technologies began to be evaluated within a farming systems context (Anderson and Hardaker [1979], CIAT [1973-1979], CIMMYT [1974], Valdes, Scobie and Dillon [1979]).

This more recent approach to technology evaluation and adoption has been as well a response to past failures. In addressing the food problem of developing countries, initial solutions emphasized the en masse utilization of inert technology such as new seeds; first called miracle seed, then high yielding varieties and currently designated with the more sober term of modern varieties. These seeds were only high yielding under favorable conditions of soil, climate and fertilization and their adoption rates among peasant farmers remained low. The emphasis then shifted toward technological packages of new seeds in combination with appropriate production practices. The use of technological packages was often accompanied by additional services such as credit and extension. Thus, the use of technological packages, also known as Integrated Rural Development programs, was a direct product of the increasing awareness of the complexity of the peasant farming system. This awareness of the complexities of the peasant farming system led to more formal and better defined research objectives.

Since most of the research on commodities for the developing

countries is now initiated at the international centers, the methods used to evaluate the new technologies have acquired justified importance. Schemes such as the Plan Puebla, in cooperation with the Centro Internacional de Mejoramiento de Maiz y Trigo (CIMMYT), the Village Level Studies sponsored by the International Center for Research in the Semi-Arid Tropics (ICRISAT), and the On-Farm Technology Trials by the Centro Internacional de Agricultura Tropical (CIAT), of which this study forms part, are examples of current attempts to obtain the feedback necessary for useful farm technology development and redesign (Roumasset, Boussard and Singh [1978], Binswanger and Ruttan [1976]).

The adoption process for a new technology depends both on the factors affecting the farm unit and the farmer's utility of income. A schematic representation of this process is contained in Figure 1.1. The utility for income accounts for the household's precautionary behavior and has led to the study of risk aversion for peasant farming. Factors affecting the family and firm are also important in understanding risk averse behavior in the adoption of new technologies by peasant farmers (Johnson [1978]). That is, farm production units are affected by the biophysical environment, the culture, the institutional infrastructure, and the existing production technologies. Thus, technology is just one of the elements affecting the farm unit behavior and the characteristics of household income.

The adoption of new technology is a function of the levels of the other elements which impinge on the farming system as much as the technology itself. The identification of the roles of the various factors affecting adoption is at best a formidable task. The approach argued in the present context groups these factors into two biophysical

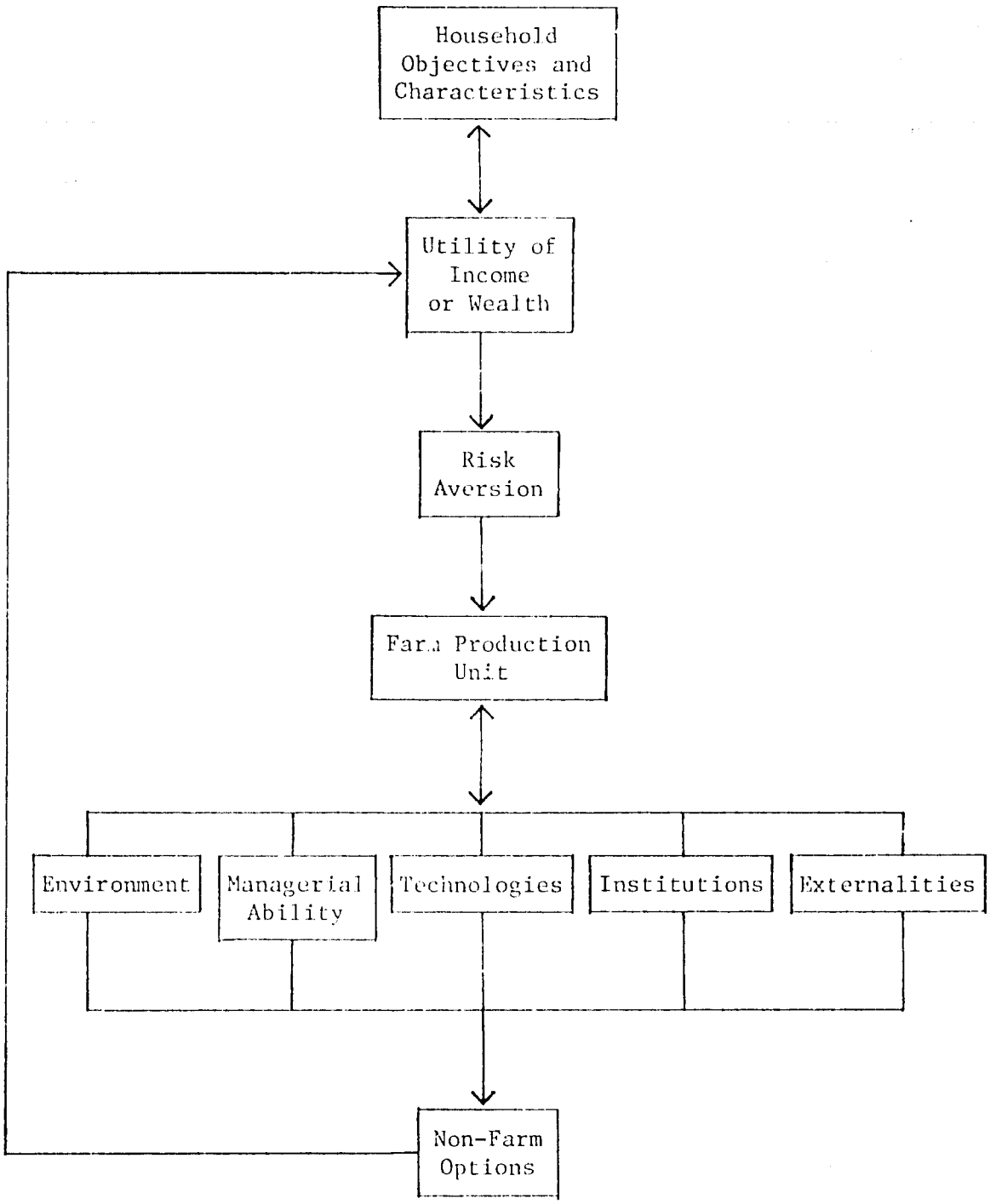

Figure 1.1. New technologies in a small farm system context.

Source: S.R. Johnson, "Risk and the Adoption of New Technology: Some Reflections on Research Alternatives," University of Missouri-Columbia, 1978. (Mimeographed.)

and socioeconomic blocks, with the technologies and the environment constituting the first one and institutions and management the second.

Results at the international centers indicate that current technologies can be improved by further adaptation to localized environments. By contrast, substantial progress in the current store of genetic material and/or new variety development can be obtained only at a high cost (CIAT [1978]). The tendency towards the generation of intermediate technologies--that is, technologies which are marginal improvements over the current ones--for the small farm systems reflects the recognition of the role of the non-biological factors. The tendency is to make more efficient use of existing technology by utilizing institutional policy instruments in promoting adoption. Thus, it has come to be recognized that small farm technology needs to embody special characteristics. First, technologies need to be highly location specific. Second, technological packages need to be developed in combination with institutions. And third, they must be more thoroughly evaluated prior to their final release and for diffusion (Valdes, Scobie and Dillon [1979]).

Evaluation of New Technology

Given the serious manpower and budget limitations for technology research, the approach to the organization of large international centers for basic crop research seemed obvious. The uncertain payoff from biological and phenological research should limit resources allocated to this activity. But, the research and testing process used by such research centers has emphasized the development of partially finished technologies which are later adapted by the national

research programs for local use at a reduced cost.

A case in point is the Bean Program at CIAT. The technology development process involves three main components (Figure 1.2): A primary phase at the experiment station for the initial screening, a second phase at the regional level for localization, and a third phase at the farm level recognizing the special circumstances of peasant agriculture. The results are used for intermediate technology design. Associated technologies thus obtained can be disseminated to many regions within an ecosystem for final adaptation (CIAT [1978]).

The present study is an offshoot of the on-farm technology trials, the main component of the third stage of technology development. The objective of the on-farm trials is to evaluate the economics of new technology which has already proved to be agronomically satisfactory on the experiment station in a more realistic context. The emphasis is on assessing the new technologies for fit into the farmer's production system rather than on yield levels alone.

Objectives of the Study

Objectives of this study are: (1) to assess on an *ex ante* basis the relative impact of new bean technology on a small farm system, (2) to relate this impact to precautionary behavior in the risky farming environment, and (3) to evaluate the impact of two selected institutional changes on risk perceptions and their consequences for technology adoption. It can be viewed as an extension of an ongoing process of technology evaluation at CIAT with the purpose of guiding technology development and adoption in peasant farming.

The study then corresponds to a necessary step in the

	I	II	III
Type of Product	Basic or Non-Site Specific Research	Regional Adaptation Site-Specific Research	Farm Level Adaptation
Location	Experiment Station	Regional Experimental Sites	Farms in Target Areas
Output	Production of New Germplasm and Basic Information for Future Germ-Plasm Production	Site Specific Work Principally on Adaptation to specific Conditions, Fertilizer and Herbicide Response	Is the New Technology Profitable, Risky? Does it Fit into the Farmers' Production System? Other Farm Level Constraints?
Information Flows of Farm Level Testing	↑	↑	

Feedback Principally to the Various Sites of Bean Program Experimentation

→ On to the National Centers and Extension Services for Further Testing and Diffusion

Figure 1.2. Stages of the research process.

Source: CIAT, Annual Report 1978, Cali, Colombia.

methodological chain established at CIAT (Figure 1.3), the on-farm technology trials. Results of these trials are first analyzed for statistical yield differences. If statistical differences among the different technologies are found, then they are screened by budgeting methods using profits as the decision rule. Finally, the screened technologies are evaluated within a whole farm context to provide information on their potential for integration within existing peasant farming systems.

Within this framework several related objectives can be simultaneously addressed. These are:

a) To assess the feasibility of new bean technology for the small farming systems.

b) To assess the potential impact of new bean technology on farm income and employment.

c) To establish the boundaries limiting the capabilities of new bean technologies from an ex ante viewpoint.

d) To assess ex ante the factors limiting technology adoption.

e) To establish the degree of risk aversion among peasant farmers and to relate risk averse attitudes and household objectives to adoption potential.

f) To measure the impact of risk aversion on farm income and employment for the small farming systems.

g) To estimate the impact of institutional changes for technology design and adoption.

h) To establish a set of decision rules for technology design and institutional change which can lead to adoption on a broadened scale.

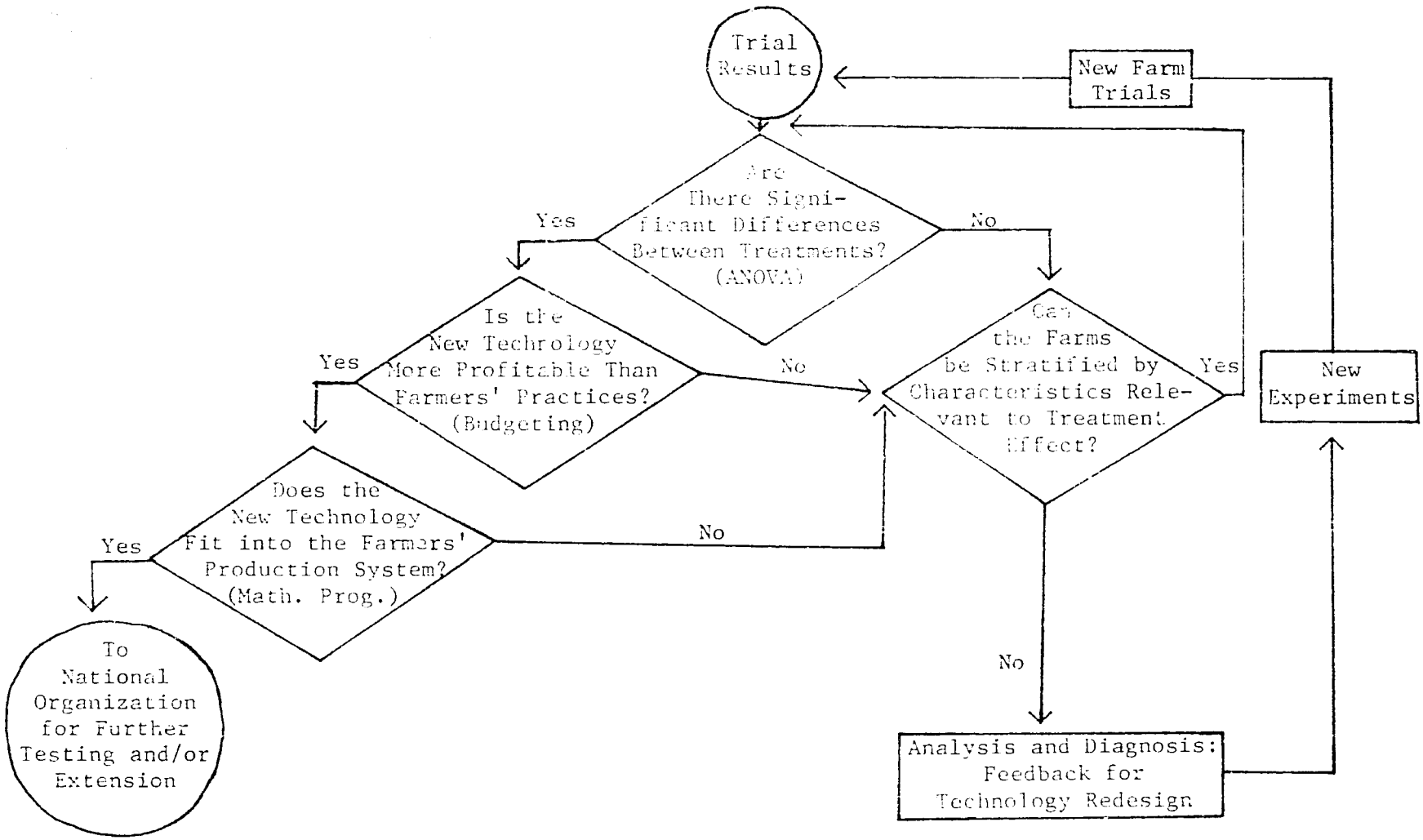

Figure 1.3. Flow chart for farm trial analysis.

Set within the framework described, this study attempts to answer two important policy questions. Presumably, new technologies increase farm output, generate higher farm incomes and account for welfare gains in the target regions. As a first policy problem, these assertions need substantiation. It is not entirely clear how the availability of new technology to peasant farmers can automatically lead to a sustained increase in the economic development of the agricultural sector. At the farm level, risk attitudes affect adoption decisions. The problem is to package currently available technologies and develop new ones so that farmers find their adoption attractive. Casting the problem in a risk aversion framework indicates a need to know more about attitudes towards risk than simply that they exist. Second, understanding farm behavior and the factors conditioning it implies that understanding the impact of controllable institutional factors is as important as plant breeding and technology generation in providing for change in peasant agriculture. Thus, an integrated approach is necessary, recognizing changed technology as just one of the factors that affect changes in peasant farming systems.

Methodology

The normative model used as a basis for the experiments is of the portfolio or risk programming type (Anderson [1973, 1974, 1976], Anderson, Dillon and Hardaker [1976], Hazell [1970], Johnson [1967]). Physical responses from time series and cross section data and judgmental experiments are used to construct estimates of yield distributions for new and traditional technologies available in the study region. With these yield distribution estimates, information on the

associated input levels, input and output prices and appropriate constraints on fixed factors, a standard risk programming model is developed. Risk aversion parameters for low income farmers obtained from interviews are introduced along with risk aversion coefficients determined implicitly by considering the new and existing options and forcing the solutions implying the maintenance of traditional methods within the framework of the risk programming problem.

With yield response data for the new and established technologies, input costs, output prices, and fixed factors at representative levels and an appropriate risk aversion coefficient, the potential for modifying the institutional setting to encourage new technology adoption is considered. Using a risk programming formulation the proposed changes in institutions are analyzed for their potential impacts on: net returns from alternative enterprises and their distributions, production decisions for representative farms, and the financial status of the peasant farmer.

The institutional and environmental changes are structured for introduction into the risk programming model by altering the constraints, prices, and variances; the latter being of utmost importance for technology design. Resulting solutions are examined for an ex ante analysis of the potential impact of the prescribed changes in institutions and technological variables on the adoption of new technologies and income levels of the representative low income farmers.

The methods just described are applied in the development of prototype models at the firm level based on information collected by the Centro Internacional de Agricultura Tropical in Palmira, Colombia (CIAT). The region of study is Southern Huila, one of the most

important bean producing regions of Colombia. Southern Huila is characterized by large cattle farms and extensive cropping on a few farms, and a large number of small farmers engaged in semi-commercial agriculture. Since this pattern is typical of many Latin American farming areas, the results from Southern Huila may be extrapolated to other similar regions in other countries with the consequent savings in time and funds. In addition, this area was chosen by CIAT as the site for its on-farm technology trials since Southern Huila is also a representative ecosystem for bush bean production.

Simulations

Since the model is a prototype, simulations of new technologies and institutional change are especially important. On a more specific level, the simulations show the effects of the institutional or policy variables examined and their sensitivity to assumed conditions for their application. Also, simulations of the technology set are undertaken to indicate how the model can be employed for developing and assessing research strategies.

The simulation process is laid out in three stages. The first stage relates to the introduction of two new bean technologies into the Huila farming system: improved agronomy and storage. The former emphasizes increases in yield per hectare at the lowest cost while the latter concerns the use of inexpensive storage methods to avoid the effects of price collapses after harvest. The second simulation stage involves price stabilization through a marketing board activity in combination with the above-mentioned technologies. The results establish relationships between price policy and technology adoption at the farm

level. The third and last stage concerns use of variance reduction as a way of measuring effects of improvements in technology design, i.e., yield stability. Again, this last element is combined with the technological and policy variables to measure its impact. These exercises are admittedly oversimplifying but present the option of specifying in a simulated context, (1) the characteristics new technology would have to exhibit to result in adoption and (2) how adoption is related to controllable institutional factors.

The methods used in choosing the experimental factors for the simulations follow standard principles of experimental design. Results of the simulations are examined in a response surface context. The development and presentation of results from the simulations using these response surface methods is especially important in the case of the prototype model since it allows simple and understandable communication of the capabilities and characteristics of the models.

Organization of the Study

The subsequent chapters are organized as follows. Chapter II reviews the previous work on technology adoption, emphasizing the empirical results obtained after the Green Revolution. Subsequently, the chapter reviews work in the study area and in related areas by national and international organizations. Finally, the discussion addresses, albeit briefly, the Bean Program at CIAT and its impact in the study area.

Chapter III describes the study area and the available data. The discussion details the farming activities and technologies, new and old, currently available to the small farmers. Data and production

technologies are then used to construct a covariance matrix of gross margins for farm activities. This measure of uncertainty is then assessed for weaknesses from a data viewpoint.

The risk programming model is set out in Chapter IV. The discussion begins with a brief exposition of the portfolio selection problem in farm planning and continues with a mathematical statement of the problem set in a risk program format. Emphasis is on the introduction of risk into the programming model and the selection and eventual introduction of institutional change variables into the model.

Chapter V deals with problems of aggregate production and price data. The use of judgmental input as an alternative is suggested for farm decision modeling. Then the collection methodology for this judgmental data on prices and yields is reviewed. Finally, price and yield distributions developed using these methods on a sample of farmers in the study area are provided.

The risk programming results for the introduction of new technology under existing institutions is the subject of Chapter VI. The chapter discusses the solution of the simulations of new technology. Similarly, Chapter VII discusses the results of the storage, price, and variance reduction simulations which form part of the introduction of new policy alternatives.

Chapter VIII is perhaps the most important part of this study as it analyzes the results relating the different factors for their implications for technology research design. Among the issues examined closely are the research strategies of international centers, the implications of risk aversion for adoption, the impact of institutional changes, and their corresponding implications for resource allocation

in research. The study concludes with a brief summary of the main results, their limitations, and the implications for future research.

CHAPTER II

TECHNOLOGY AND THE SMALL FARM SYSTEM

Introduction

The principal objective of this chapter is to briefly review and summarize the previous work done in the area of technology development and adoption as related to peasant farming. As discussed previously, the combination of agronomy and economics as a criterion for generating appropriate technologies for semi-subsistence farms is relatively new. The bulk of the experience in economic development prior to the creation of the network of international centers was concentrated on policy instruments, i.e., credit, crop insurance, etc. aimed at increasing farm production regardless of the type of clientele served. Moreover, there was usually a continuous lack of coordination between government policies aimed at increasing the supply of food and policies for maintaining low consumer food prices (Biere, de Janvry and Schmitz [1972], Jorgenson [1979], Long [1973], Peterson [1979], Thirsk [1973]). As a consequence, incentives for innovation and adoption of new techniques were often lacking. Furthermore, in cases where awareness of this type of policy conflict occurred, the efforts in promoting the adoption of innovations were hindered by the lack of appropriate technologies or conditions for the adoption of existing technologies (Anderson and Hardaker [1979], Binswanger and Ruttan [1976], Valdes, Scobie and Dillon [1979]).

With the advent and subsequent use of new varieties there arose the issue of the welfare gain from new technology. Although great success was obtained with rice and wheat, the ex-post evaluation of technology adoption and benefits from new technology left standing the problem of unequal gains from the new varieties. In other words, poor farmers were still poor. The main reasons seemed to be the inert nature of new seed technology on prime land versus a poor performance on marginal land, and the lack of appropriate technological packages for the small farm system. The need for reapproaching the peasant farm population was obvious (Arndt and Ruttan [1977], Falcon [1970], Scobie and Posada [1978]).

The equity issues raised by the unbalanced welfare gains of the Green Revolution brought an ensuing shift in research methods for new technology. In general, the biggest change occurred from merging biologic and socioeconomic research into a more coherent structure. Thus, the problem of developing adequate technology packages became more clear (de Janvry [1977], Dent and Anderson [1971], Obschatko and de Janvry [1972], Sanders and Lynam [1979]).

The Technology Adoption Process in Latin America

The process of technology development in Latin America has slowly evolved from a framework of classic economic dualism, i.e., development of infant industries and benign neglect of the peasant sector, to a structure of conflict between a Schultzian view of the small farm system, i.e., poor but efficient farmers, and a socio-political view, i.e., exploitation of the small farmer on the periphery by the capitalist center (de Janvry [1975], Harwood [1979], Jedlicka

[1977], Mosher [1966], Schultz [1964]). The latter is important for economic development since it implies political, rather than technical, solutions.

The exploitation of the periphery by the center is a theory best argued for Latin America. Briefly, it states that the unequal development of the industrial and commercial sectors of an economy vis-a-vis the impoverished rural sector is a consequence of an unfair process of capital accumulation by the rich at the expense of the poorer sector. It is, in essence, a theory of exploitation. Obviously, under such framework the issue of appropriate technologies for the small farm system is irrelevant since such technologies could not alter the level of inequality between the two sectors. Poor farmers would remain poor. A solution for the peasant farming sector would entail substantial changes in the political system, the distribution of resources, and the social conscience of the population.

The Schultzian view of the small farm problem, on the other hand, is more tailored to the viewpoint of the existing international institutions since it allows a very positive role for new technology without undergoing substantial structural changes in the social and political systems. According to Schultz's theory, small farmers are poor but efficient. Reasons why they remain poor are found in the highly constraining environment in which small farmers operate. Hence, the solution for farm poverty is achieved through the use of new technologies which can aid in surmounting the environmental constraints more effectively along with the required institutional structure to support the new technology (Arndt, Dalrymple and Ruttan [1977], Barraclough [1973], Benito [1975], Binswanger and Ruttan [1976],

CIMMYT [1974]).

Clearly, the Schultzian view of the small farm problem fits well into the international center network, by intent generators of technologies. However, such view of the small farm system as an entity independent of or immune to political forces needs to be reconciled with the theory of exploitation. So far, the empirical evidence suggests that current efforts are directed in that direction.

A case in point is the Plan Puebla in Mexico. Plagued by low adoption rates the Puebla Project evolved from a pure technology demonstration package to a complex biophysical-behavioral model designed to bring peasant farmers into the economic mainstream at a faster pace. When compared with the program implied by the center-periphery theory the Puebla Project is still a naive effort. Nevertheless, the point has been recognized, at least implicitly. The accumulated experience from the project tends to support the center-periphery view; that induced innovation at the small farm level is not a linear process, as suggested by Hayami and Ruttan, but rather a dialectical interaction involving both technical factors and political institutions (Andersen and Franklin [1977], Hayami and Ruttan [1971a, 1971b], Ryan and Subrahmanyam [1975]).

Technology Adoption in Colombia

Prior to the creation of CIAT the process of technology development in Colombia was concentrated mostly on field crops and the adaptation of imported lines to local conditions. During the late fifties and early sixties the development and promotion of new varieties involved crops more suitable for large scale farming and

mechanization. Despite several drawbacks this scheme proved somewhat successful for rice, cotton, and soybeans (Hertford, Ardila, Rocha, and Trujillo [1977]).

The varietal development program for rice was initiated in the early fifties and focused on a variety resistant to the hoja blanca virus. With the founding of CIAT and the initiation of cooperative programs between CIAT and the Institute Colombiano Agropecuario (ICA) some International Rice Research Institute (IRRI) bred varieties were introduced with relatively high success. However, the new rice varieties were unsuitable for upland production, the location of most peasant farms.

Cotton, another field crop, presents a highly successful picture with yields equal to or better than in the United States. Again, technological innovation was induced by favorable economic conditions and the coordinating efforts of a powerful federation of cotton growers. The case of adoption of new technology among soybean producers was almost identical. In contrast, technology development and promotion for wheat, a small farm crop, was a total failure. As Hertford et al. report, wheat acreage and production in Colombia have declined over the past two decades. This paradox, they suggest, is explained by the disincentive effect brought about by parallel PL 480 wheat sales to Colombia in combination with a lack of coordination and power among the numerous small wheat producers.

The emphasis on small farm research in Colombia is recent. Governmental concern for the peasant farm was initiated in the early seventies in the form of Integrated Rural Development schemes currently in effect in several small farm regions. The results have been

encouraging in terms of development experience but have yielded mixed results.

The case of Eastern Antioquia is perhaps the most notable success. Endowed with excellent climatic conditions this small farm region was somewhat of a challenge. A typical Eastern Antioquia farm had an average of 4.4 hectares of undulating land mostly unsuitable for mechanized farming. Principal crops are potatoes, high altitude corn, climbing beans, and vegetables. The basic problem was low yields due to diseases and pests, along with a very low per capita income and large family size (an average of 12 persons per household). By relying heavily on improving the yields of existing crop rotations (e.g., potatoes to corn, beans to corn, beans to potatoes), heavy fertilizer and pesticide applications, and health care promotion, substantial improvements in farm income were achieved (Alvarez [1977], CIAT [1976, 1979]). Farm history and production records are kept in a technical file at the ICA office along with records of corresponding gains in awareness by the extension agents of the specific problems affecting each farm. Hence, the highly disaggregated level of farm data enable the extension service to have a better grasp on the trade-offs involved in technology generation and adoption.

Another region where a similar program yielded a different degree of success is Caqueza, in Eastern Cundinamarca (Escobar [1973], Swanberg and Escobar [1975], Zandstra and Cillamizar [1974], Zulberti, Swanberg and Zandstra [1979]). As in the case of Eastern Antioquia researchers did not attempt to bring radical changes to existing farming patterns but rather to improve the ones in current use. The Caqueza Project, a joint venture of ICA and the International Develop-

ment Research Center, was initiated in 1971 with a series of field trials for corn and potatoes, the two most common crops in the region. Using methods similar to the CIAT on-farm trials, researchers identified technologies which, with a few modifications over the traditional methods, yielded a 202 percent gain in corn yields and a 235 percent in net income from corn, and a 51 percent gain in potato yields with a corresponding 30 percent gain in net income from potatoes.

The corn technology was based on the use of fertilizer and pest control, along with a higher plant density and a new variety. The traditional technology did not require use of fertilizer or pest control. The traditional cultivation method for potatoes, however, involved a heavy use of fertilizer and some pest control. The new technology emphasized a higher plant density and new seed as the key elements for yield gains.

In addition, the supply of governmental credit was expanded to allow farmers to purchase the necessary inputs and to extend the area of cultivation. The results for adoption rates were somewhat surprising. The demand for credit allocated to potatoes exceeded the supply, while the opposite occurred for corn. Nearly 70 percent of the farmers in the region adopted the new potato technology in its totality while 83 percent adopted the new corn seed totally and the fertilizer recommendation partially. Why would farmers totally adopt a technology increasing net income by 30 percent while partially ignoring another one yielding a net income gain of 253 percent? Caqueza Project researchers were able to isolate the following factors:

a) While the potato technology increased total investment requirements by 12 percent and cash inputs costs by 10

percent the corn technology required an increase of 170 percent in the total investment and a 575 percent increase in cash input costs. Given the per capita income for the region, the allocation for cash inputs in the new corn technology was excessive.

b) Despite the more intense use of capital the corn technology presented lower returns to capital than the potato technology.

c) Using the expected value of the loss as a measure of risk from each technology, produced results indicating that the new potato technology had similar expected losses increments for total costs and for cash input costs. In contrast, the new corn technology presented an 111 percent increment in the expected loss for total cost while the expected loss for cash input costs increased by 1,530 percent.

d) The labor requirements for fertilizer application for corn coincided with the period of high labor use in the region.

Based on the above results researchers initiated another series of experiments. The new technologies in this second round presented more modest increments in both costs and profits but with better degrees of success in terms of adoption. The important point, as elementary as it may seem, is that researchers were able to identify the matrix of constraints to new technology adoption and the types of new technologies which would be appropriate for the Caqueza region.

Figure 2.1 synthesizes the prototypes of technologies derived from the Caqueza project and beneficial for future ex ante technology

		Socioeconomic	
		Requirements Within Limitations	Requirements Beyond Limitations
Biophysical	Requirements Within Limitation	I (Potatoes)	II (Corn)
	Requirements Beyond Limitation	III	IV

Figure 2.1. Relationship between technology types and the biophysical and socioeconomic environment.

Source: Carlos A. Zulberti, Kenneth G. Swanberg, and Hubert G. Zandstra, "Technology Adoption in a Colombian Rural Development Project," in Economics and the Design of Small-Farmer Technology, ed. Alberto Valdes, Grant M. Scobie, and John L. Dillon (Ames: Iowa State University Press, 1979).

evaluation for the region. Technologies falling in the Type I cell would be easily adopted since they fit into the farmer's production system. Technologies of Type II are physically appropriate but do not overcome the socioeconomic constraints. Technologies of this type are common and account for most of the failures related to technology transfer. Type III technologies relate mostly to technologies which failed to work in the field, despite being within the socioeconomic realm of the peasant farm. Pesticides or fertilizer applications or seeds not adapted to a particular region fall in this category. Finally, Type IV technologies are those which do not fit the small farm system either biophysically or socioeconomically. Some of the "high yielding varieties" of the early Green Revolution fall in this category.

The common factor among the different rural development schemes currently operating in Colombia is the high effort involved in identification of technologies of Type I. CIAT and similar research institutions are involved in the generation of technologies of all four types. It should be obvious that a great deal could be gained by identifying the changes needed in the farming environment to enable technologies of Type II, III, and IV to become technologies of Type I. So far, the current attempts on this area are at a preliminary stage.

CIAT and the Generation of New Bean Technology

The Centro Internacional de Agricultura Tropical (CIAT) is the only research institution in the world doing research on pulses on a large scale. Besides beans, the center also deals with basic research on tropical pastures and cassava, and serves as a relay station for IRRI's rice research and for CIMMYT's corn research. Current work on

small farm systems is relegated to the identification of technologies of Type I through the on-farm technology trials and ex ante evaluation of the trial results on whole-farm bases. Prior to the establishment of the on-farm trials, however, the economics section of CIAT was engaged in an extensive preliminary survey of the beans farms to identify the biophysical and economic constraints to bean production (Fernandez and Franklin [1973], Francis, Flor, Prager and Sanders [1978], Francis and Sanders [1978], de Londono, Andersen and Infante [1978], de Londono, Andersen, Sanders and Infante [1978], Andersen, de Londono and Infante [1976]). The results of the biophysical section of the survey are summarized in Figure 2.2. The use of associated cropping, such as corn and beans in the same field, accounted for nearly one-fifth of total bean yields possible. Another fifth of total yield is lost to disease and pest incidence. Close to seven percent of total yield is lost because of land quality, a factor endemic to most peasant farms, and the remaining 2.7 percent is lost to low plant density and excess humidity.

Partially based on the survey results, representing the demand for new technology, CIAT initiated the farm level trials using bean technologies considered most appropriate for the region. The initial trials occurred during the first semester of 1978. The new technologies tested were based on three main components: seed quality, fertilizer use, and agronomic practices (Restrepo [1979]). Seeds are important not only for higher germination rates and plant vigor but also for transmission of viral and fungal diseases. Fertilizer is an important element for farm production in Huila due to the low fertility characteristics of Southern Huila soils. The third component, agronomic

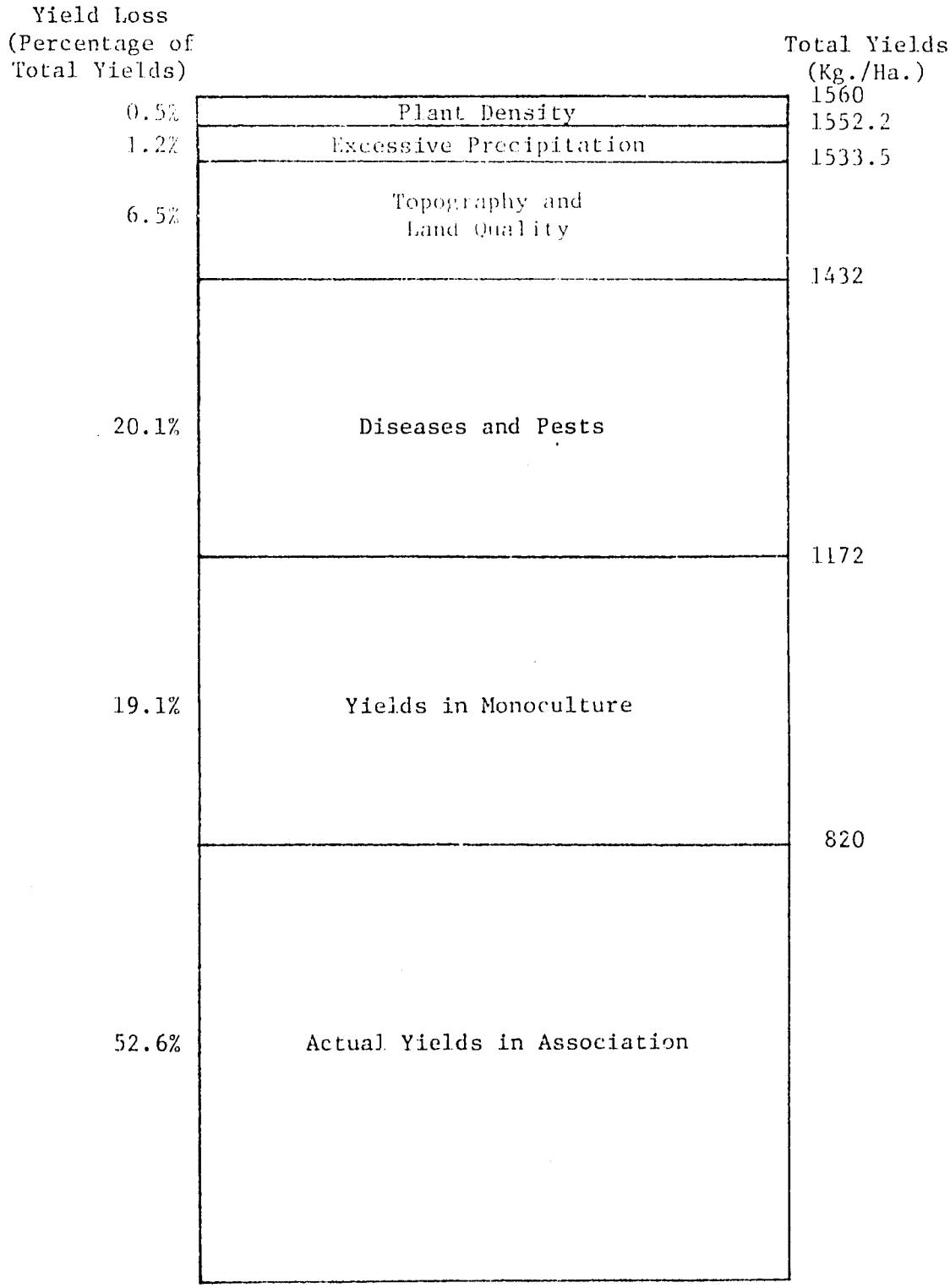

Figure 2.2. Estimated yield reduction due to biophysical factors in Southern Huila.

Source: Ruiz N. de Londono, Per Pinstrup Andersen, John H. Sanders, and Mario Infante, "Factores que Limitan la Productividad de Frijol en Colombia," CIAT, Cali, Colombia, 1978.

practices, was aimed toward mechanical means of controlling bean pests and diseases. Five basic treatments were evaluated:

a) Protected seed,[1] no fertilizer.

b) Protected seed, 200 kilograms per hectare of 10-30-10 fertilizer.

c) Protected seed, 400 kilograms per hectare of 10-30-10 fertilizer.

d) Commercial certified seed, no fertilizer.

e) Farmer's seed, no fertilizer.

The sample population was divided into farms of low or adequate fertility depending on absolute levels of phosphorus and potassium, and/or high soil acidity. The results of the trials showed that with the implementation of better agronomic practices such as two weedings and opportune spraying, yields would increase more than 50 percent (Figure 2.3). In the cases of fertilizer and clean seed the results were not as encouraging. A significant response to fertilizer was observed only on the low fertility plots and, in general, the farmer's own seed proved to be equal, if not superior, to both clean and certified seed. To translate the physical response into an economic one, a partial budget comparison was made between all the treatments and a control group representing usual farm practices in the region. The overall net income comparisons are shown in Figure 2.4. On farms where soil fertility was adequate the agronomic practices (Point E) gave higher earnings than any of the other technologies. Other technologies such as unfertilized clean seed (Point A) and clean seed under low levels of fertilization (Point B) also gave higher earnings than the local technology. In the case of low fertility farms the response to

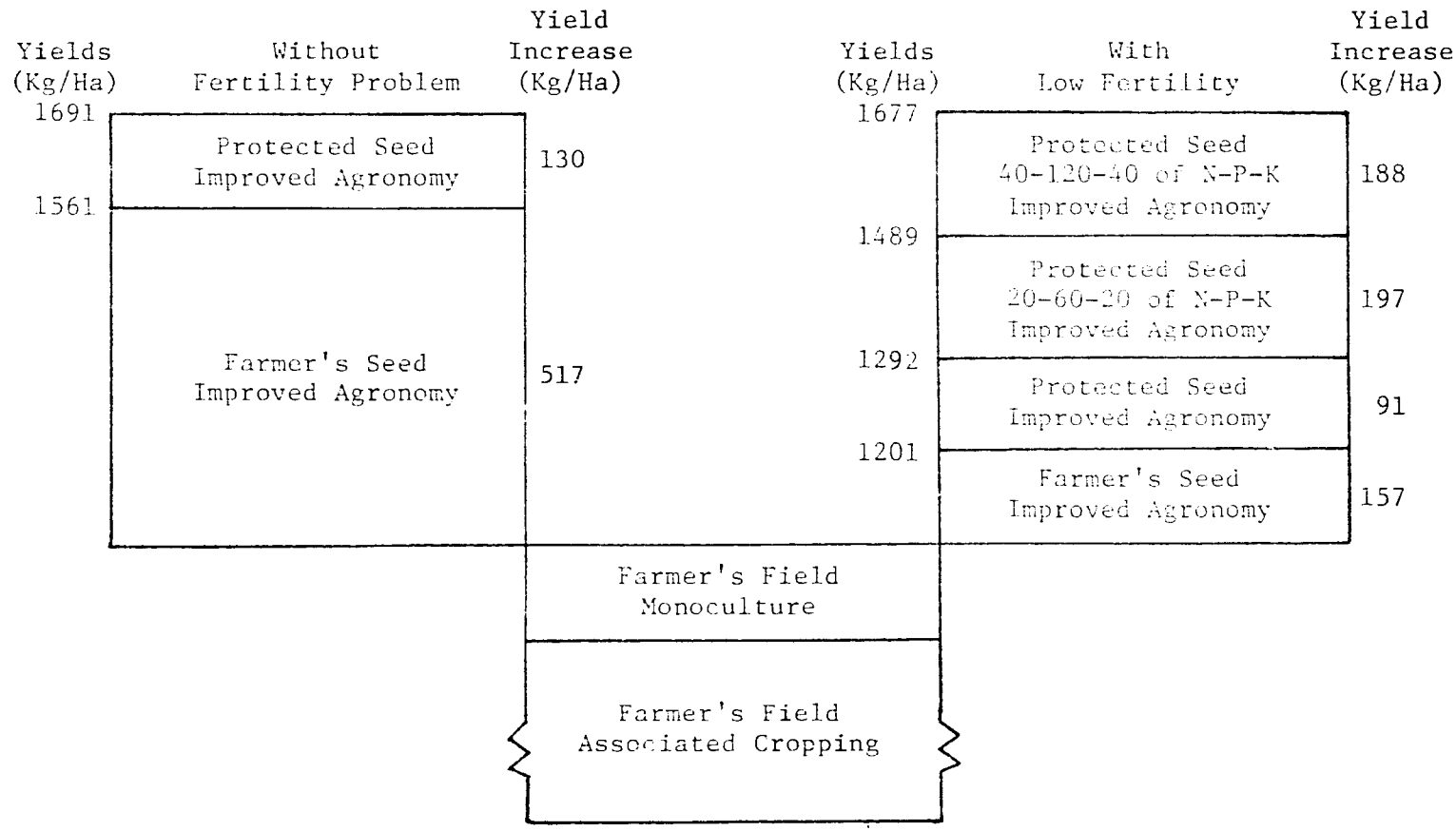

Figure 2.3. Effects of different factors on yields in the farm trials, Huila, Colombia, 1978-A.

Source: CIAT, Annual Report, 1978, Cali, Colombia.

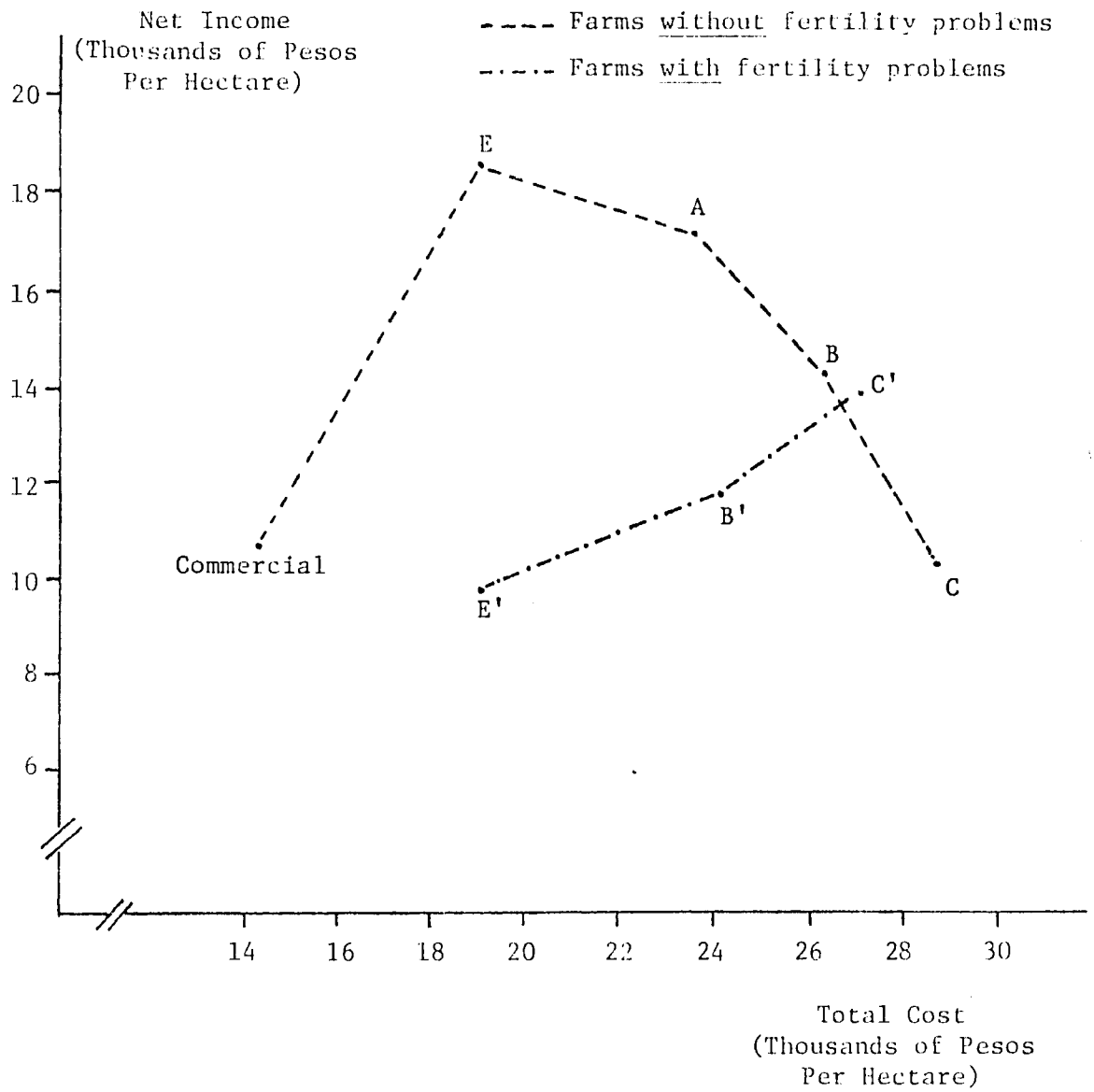

Figure 2.4. Net income and total cost of production of beans by soil fertility for relevant technologies in Southern Huila, 1978-A.[a]

Source: CIAT, Annual Report, 1978, Cali, Colombia.

[a]Assumes a 50.0 pesos per kilogram cost of production for protected seed.

fertilizer was sufficient to be profitable. In summary, utilizing simple budgeting analysis the recommended technology was Technology E, the better agronomic technology, for fertile soils and C, the high fertilization technology, for the farms with fertility problems.

The technologies tested in 1979 did not differ substantially from the technologies tested in 1978. They were:

a) Improved agronomy as in 1978.

b) Improved seed quality.

c) Use of herbicide.

d) Seed treatment.

e) Fertilization.

f) New variety, BAT-47.

The results for 1979 indicated that better agronomy again significantly increased profits on farms where soil fertility was considered adequate. Thus, after two consecutive years of trials on 50 different farms the results indicated that the Better Agronomy technology was appropriate for ex ante evaluation on a whole-farm basis (see Table A-2.1 for budget). A preliminary evaluation of this option was completed through linear programming models of typical Southern Huila farms. The results from the evaluation pointed out that better agronomy alone had little effect on farm income due to the high profitability of other alternatives such as coffee grown with modern methods of cultivation. However, combining the better agronomy technology with on-farm storage provided strong economic incentives to adopt the package.

The storage technology utilized in the LP model did not develop from the farm trials but from separate trials carried out by the

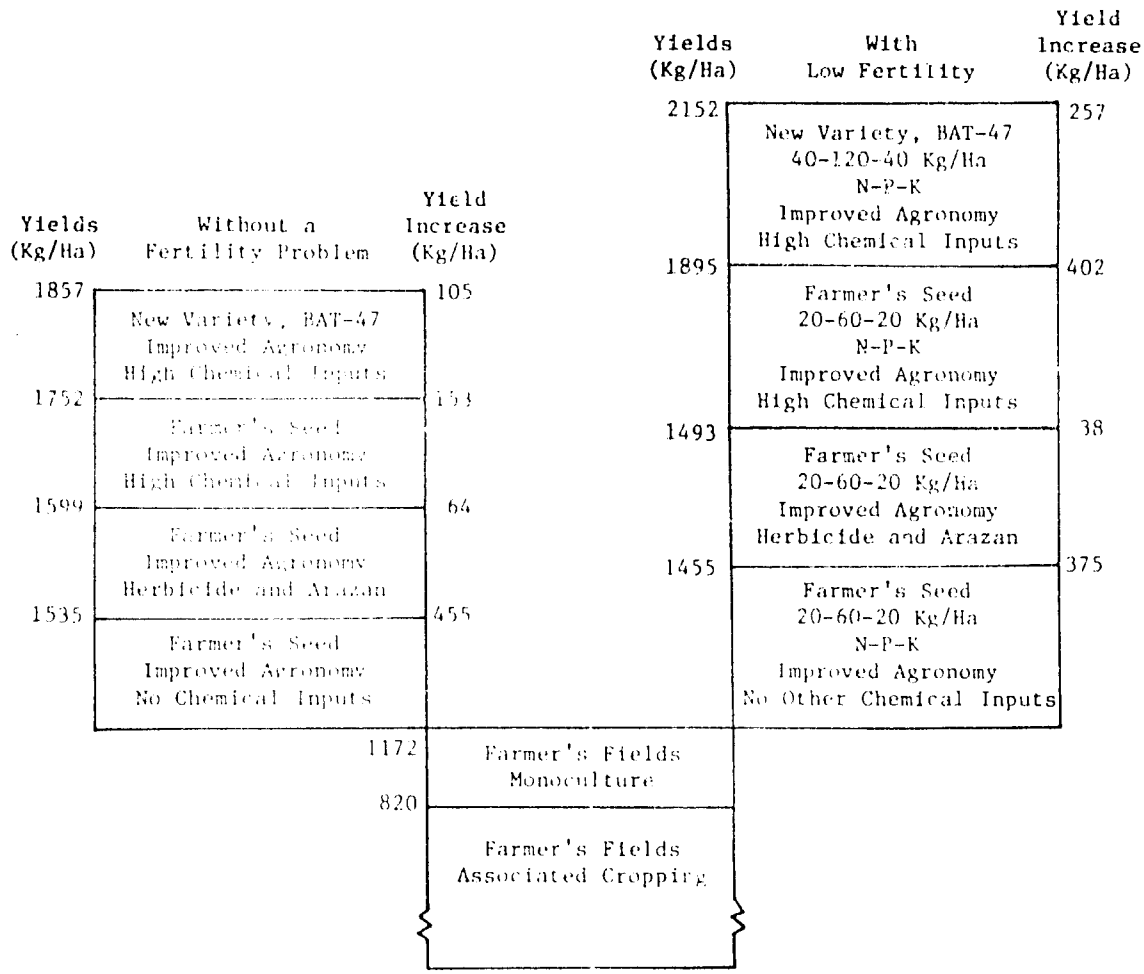

Figure 2.5. Effects of different factors on yields in the farm trials, Huila, Colombia, 1979-A.

Source: CIAT, Annual Report, 1979, Cali, Colombia.

technology section of CIAT as part of their research program. Presently, little on or off-farm (controlled by farmers) storage of beans exists. Various factors have contributed to this situation but the major one is an insect problem, the bean weevil. Methods for controling this insect have been developed and applied in an on farm context (Bowman [1979], Schoonhoven [1976, 1978]). Thus, storage is a technically feasible activity in which farmers can engage as a basis for changing the price received for output and the price of purchases for home consumption and seeds.

The budget for on farm storage is included in Table A-2.2. It is assumed that farmers used 55 gallon (used) drums for storing the beans. Other alternatives include the use of burlap bags as containers, tied from the roof of the house. The budget using barrels was developed because of the more extensive on farm experience with this storage method. The treatment is to dry the beans, as reflected by the labor requirements, and then coat them with a thin film of cooking oil. The cooking oil is easy to apply and is successful in preventing the attack by the bean weevil. Other methods which have been tried include chemicals, not always available, and dusting with bean pod or actually storing the beans in the pods. The chemical preventatives are effective in retarding the weevil. Other methods are much less effective than oil and chemicals, which are comparable. The oil treatment was chosen because of its simplicity and availability in the more remote farming areas.

As the method involved the use of barrels, no economics were assumed. The budget in Table A-2.2 was developed for the average yield of one hectare of beans produced with the traditional technologies.

However, it may be adapted to the newer technologies by simply scaling-up the input requirements proportionately to the larger volume of beans. Separating the effect of each component in the technological package (i.e., better agronomy and storage) resulted in relatively low gains for the small farm. Furthermore, the returns to capital were too low to make each alternative attractive. When combined, however, better agronomy and storage resulted in large income increases and adequate rates of return on capital invested (Arcia and Sanders [1980]).

Conclusions

Despite the great deal of progress achieved in the area of technology generation and transfer, few empirical findings exist pertaining to rates of adoption of technology specifically designed for the small farm system. In Latin America, where the impact of CIMMYT and CIAT research is felt the most, only the Plan Puebla in Mexico and the Caqueza Project in Colombia have addressed the small farm issue systematically. Other areas of the world where similar work is being carried out are in India (through ICRISAT), the Philippines (through IRRI) and Northeast Brazil. Their work, however, is still in the initial stages (Albuquerque Lima and Sanders [1976], Evenson, O'Toole, Herdt, Coffman and Kauffman [1978], Herdt and Barker [1977], Jodha and Ryan [1975]). The work to date and the experience with the CIAT bean project suggests, however, that the integrated approach will be the best for assessing the potential for technology adoption on small farms. This integrated approach takes important elements of its structure from the city periphary exploitation hypothesis. That is, it is not socially or politically inert.

FOOTNOTES

CHAPTER II

[1]The term protected seed refers to a seed produced with high levels of chemical inputs to reduce disease incidence and transmission.

CHAPTER III

BASIC DATA SOURCES AND DESCRIPTION OF STUDY AREA

Introduction

The present chapter provides a summary of the basic price, yield and technology information used in formulating the decision model employed to study the technology adoption problem. The area of study is Southern Huila, Colombia (see Figure 3.1), a region which has been the focus of the CIAT Bean Program for the past several years (CIAT [1979]).

Small farm holdings in Southern Huila are characterized by diverse cropping patterns and cultivation practices. The semi-subsistence farmer of Southern Huila cultivates crops destined for home consumption and surplus and cash markets. Such a farming framework is common to many small farm areas in the world which makes the development of appropriate technologies for small farms in Huila very important.

Data on prices and technology for Southern Huila are not abundant. This is of course typical of areas in which peasant farming is prevalent. In assembling the data to be used in this study and summarized in this chapter, interviews, field trials, secondary sources and interpolation methods were all employed. The purpose of this chapter is to document the data sources and the methods utilized to generate the basic information supporting the decision models constructed

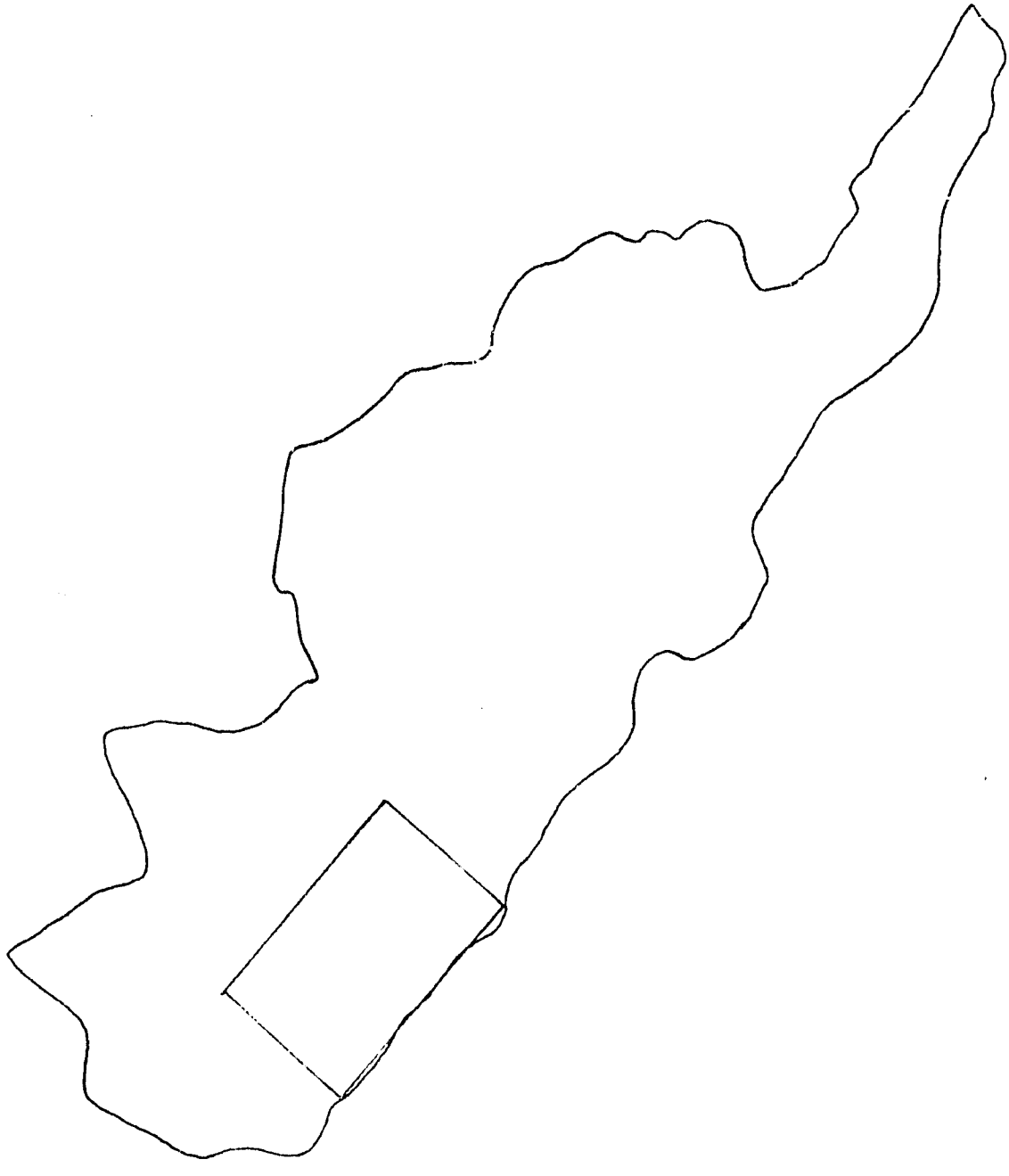

Figure 3.1. Area of study.

for Southern Huila.

The chapter starts with a general description of the Southern Huila farming area and its socioeconomic characteristics, continuing with a discussion of the major data sources. Yield data sources are summarized for the major existing crops and technologies, old and new, followed by output price information and discussion of the enterprise budgets for old and new technologies. Finally, the basic variance-covariance matrix of gross margins necessary for the risk programming model is discussed in detail.

Area Description

Land Characteristics

The study area is politically divided into four municipios: Guadalupe, Suaza, Timana, and Pitalito. It covers approximately 1,980 square kilometers with altitudes varying from 929 to 1,300 meters above sea level with a fairly stable 22 C° of average yearly temperature. Most of the land is steeply sloped although still suitable for mechanization in the valleys. Characteristics of the soil in Southern Huila are fairly uniform. According to the Instituto Colombiano Agropecuario (ICA) surveys about 80 percent of the soil has an organic matter content of less than 10 percent, and about 65 percent present low levels of phosphorus (less than 15 ppm) especially on steep slopes. The predominant texture is clay (63 percent) but a substantial proportion (30 percent) of the soil is lightly textured.

In terms of rainfall, Southern Huila has a well defined pattern (see Table 3.1). The rainy season starts in the middle of March, reaches a peak during the last week of May and gradually diminishes

Table 3.1

TEN YEAR AVERAGE OF MONTHLY PRECIPITATION
FOR SOUTHERN HUILA

Station	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Yearly Total
Garzon (La Pita)	93.5	87.2	130.3	194.0	163.6	162.8	138.6	119.6	95.6	178.5	186.1	111.3	1661.1
Guadalupe	99.3	77.1	122.0	154.8	111.2	125.3	127.5	93.6	88.1	124.7	132.3	122.2	1377.1
Acevedo	69.6	91.4	138.5	164.5	194.0	205.3	236.0	181.0	139.5	128.7	117.0	66.5	1731.5
Acevedo (San Adolfo)	146.6	132.2	213.3	195.7	272.8	284.4	310.0	248.8	229.3	194.5	181.7	115.4	2524.7
Pitalito	79.2	94.3	158.4	171.3	160.0	196.3	201.6	138.0	120.6	155.5	137.5	109.0	1721.7
Pitalito (Palestina)	84.0	64.0	124.5	117.6	84.5	196.3	197.3	161.3	110.3	128.3	105.6	95.6	1469.3
Pitalito (La Laguna)	71.8	87.1	112.0	138.1	146.6	143.5	159.4	118.4	98.5	123.6	119.6	95.8	1414.4
Pooled Mean	92.0	90.5	142.7	162.3	161.8	187.7	195.8	151.5	125.9	147.6	140.0	102.3	1700.1

Source: Instituto Colombiano Agropecuario (ICA), Districo de Transferencia de Tecnologia Sur del Huila, Diagnostico Distrital, Regional 6, Ibague, Colombia, 1978, p. 13.

until a dry period of about two months occurs around August and September. Another rainy period, of lower intensity, starts in October with a December peak and fast roll-off in January and the start of the dry season.

The relatively good precipitation level and pattern coupled with a 75 percent humidity and adequate elevation make Southern Huila an ideal zone for bush beans and production.

Demographic Characteristics

Southern Huila has a higher than average proportion of small farm holdings. Ownership is the predominant form of land tenure and nuclear families the predominant farming units. The typical family farm is composed of seven to ten members with approximately two adult-equivalent family labor units per farm. Three quarters of the population is rural with about 45 percent of it less than 15 years old and about 75 percent less than 30 years of age. The region also has low levels of formal education and health care and a high (70 percent) relative intake of carbohydrates in the diet (DANE [1972]).

Agricultural Characteristics[1]

As with other small farming systems, the holdings in Southern Huila are characterized by diversified cropping and a myriad of cropping arrangements. Cassava, corn, and plantains are the predominant home-consumed items while coffee, beans and brown sugar from sugarcane are the main commercial items. Tomatoes and onions are special cases since they are, in most instances, produced for sale at big-city terminal markets. The major planting season is in the month of March, the beginning of the first rainy period. Since rainfall tends to be

heavy during the months of April, May, and June, weeding accounts for a large share of the farmer's time. Harvest of all crops, totally or in part as in the case of perennials, occurs in the months of June and July.

Second semester plantings of beans start in late September and harvest usually ends in middle January of the following year. Drought prone periods such as the third and fourth quarter cause corn to be virtually absent during the second semester. Bean plantings decrease considerably during those quarters and tomatoes are planted only with irrigation.

The labor utilization pattern then follows a series of peaks and valleys which affects the quantity of labor supplied. This pattern is further affected by the coffee harvest in Colombia from October to December. Peak labor demand periods during planting and harvesting tend to affect only the quantity of labor supplied. The coffee harvest, however, produces an upward shift in the labor demand curve with a corresponding increase in wages. Wages during the fourth quarter increase approximately 25 percent at the local level, creating an additional disincentive for second semester production of labor intensive crops.

Since farmers tend to cultivate about four to six crops simultaneously, the labor requirements at planting and harvesting limit the area of production. Credit sources are formal, such as Caja Agraria, and informal; relatives, private lenders, middlemen or shop-owners. Formal credit sources charge low rates of interest but also are plagued by scarcity of funds and long bureaucratic procedures. Furthermore, as instruments of government policy, such sources peg

credit availability to crop choice and/or compulsory technical supervision.[2]

In a sample of 24 small farmers who participated in the CIAT Bean Program on-farm technology trials, three-quarters had no credit at all, thus relying on their own savings and pooling neighbor or kin labor in exchange for their own services. Since such exchanges may not occur simultaneously, they may or may not be interpreted as informal credit. Only four of the twenty-four farmers or 16.6 percent of the sample had credit from public institutions. Another 16.6 percent reported that they looked for institutional credit but the Agrarian Bank had exhausted its quarterly allotment. This finding coincides with previous credit information obtained in the area in 1974 (de Londono, Andersen, Sanders and Infante [1978]).

Thus, in the predominant Huila cropping system, capital utilization is low; a direct consequence of the constraints just described. One apparent response to the deficiencies in the financial market has been the use of cropping systems compatible with low capital utilization. Shown in Table 3.2 are the input cost/total revenue ratios for the principal crops and technologies currently utilized in the area. Table 3.2 also includes the CIAT technologies as generated by the on-farm trials. It is clear that most activities for the major farm types require lower input costs than either tomatoes or the new technology options.

The marketing of farm products occurs at the local level and usually involves many intermediaries before products reach consumers (de Londono, Andersen, Sanders and Infante [1978]). Huila is a region where many of the small holdings are located in areas of difficult

Table 3.2

INPUT COST/TOTAL REVENUE RATIO
FOR SOUTHERN HUILA

Crop and Technology[a]	Ratio	Rank
Old Coffee	0.016	1
Cassava	0.025	2
Corn-Beans, Traditional	0.138	3
Caturra Coffee, Low Technology	0.164	4
Beans, Labor Intensive	0.181	5
Onions	0.200	6
Sugarcane	0.206	7
Beans, Better Agronomy Technology[b]	0.218	8
Caturra Coffee, New High Technology	0.220	9
Corn-Beans, Sprayed	0.270	10
Corn-Beans, Fertilized	0.310	11
Beans, Storage Technology[b]	0.319	12
Beans, Capital Intensive Technology	0.347	13
Tomatoes	0.510	14

[a]For a detailed explanation of each technology see budgets. All ratios are for crops on prime land.

[b]CIAT generated technologies.

Source: CIAT Bean Team field work.

accessibility. These operating conditions impose a heavy burden on small farmers, especially since storage technology for beans is not well-known and the crop is generally sold as soon as it is harvested. The farmer's eagerness to sell immediately after harvest is primarily based on his cash flow needs at harvest time (de Londono, Andersen, Sanders and Infante [1978]). Cash is needed to pay debts incurred during production, credit payments, and purchases of nonfarm products. The choice of the sale date is dependent upon the fixed "market days" in the surrounding towns. Market information for cash crops, however, is very scanty. Farmers usually know the on-going price at the nearest locality during a given week. However, the total amount harvested (and hence prices) may fluctuate highly from one week to another so that farmers face an uncertain sale price at marketing time.

Based on interviews with farmers it was ascertained that transportation is a problem due to the road conditions and aging equipment. Middlemen tend to travel relatively short distances and sell to other middlemen in a relay system designed to compensate them for market risk. Tomatoes and onions are exceptions to this system due to their perishability. It is common to find no more than one middleman between the farmer and the wholesaler for these crops. Since a few hectares may flood small local markets, tomatoes and onions are carried long distances to terminal markets in large cities such as Cali or Bogota. These crops, however, are considered very risky by everybody including the intermediaries. Such fears are justified since, as with other perishable products, tomato and onion prices vary widely within seasons.

Data

Sources of data for prices and technologies are varied. Geophysical and demographic information on Southern Huila are largely from the 1970-1971 Agricultural Census and unpublished surveys conducted by Regional Office No. 6 of the Instituto Colombiano Agropecuario (ICA). Base data on the technologies for some of the existing enterprises were obtained from a 1977 ICA survey of 377 farms in Southern Huila (ICA [1978]). This study was used as the major source of information on existing technologies for crops other than beans. The original objective of the survey was to provide the bulk of information for an Integrated Rural Development Program sponsored by the Colombian government. It contains valuable data on cropping systems. Specifically, it emphasizes input coefficients and enterprise budgets for corn-bush beans and corn-climbing beans systems, sugarcane and cassava. Different enterprise budgets are described for different levels of technology, soil quality and geographical regions. Finally, the study also provides preliminary recommendations for new technologies as well as a discussion of the socioeconomic problems found in the region.

Four additional information sources were employed to update and calibrate the coefficients from the base survey and extend the enterprise budgets to the new technologies. The first of these was the 1974 CIAT survey of all bean producing farms in Colombia (de Londono, Andersen and Infante [1978]). This survey was conducted by a multidisciplinary team which concentrated their efforts in the collection of the main agronomic and economic characteristics of the bean producing farms. The emphasis of the survey was the agronomic study of the different bean production systems; however, it also contained

valuable information on farm size, family characteristics, marketing practices and price determination processes.

A second study employed in conjunction with the ICA 1977 survey is by Alvarez [1977]. This analysis includes an assessment of distribution of yields and net returns for beans cultivated by existing and some newer technologies, as well as a summarized and updated version of the 1974 CIAT survey. The third study employed in this process is by Restrepo [1979]. This study provides the basis for the budgets on new bean technologies as generated by the CIAT on-farm trials in Southern Huila during the first semester of 1978 (1978-A).

Finally, the enterprise budgets and price and yield data were updated using a smaller survey of 50 farmers in Southern Huila conducted by the author with the logistical support of the CIAT Bean Program Team. This activity occurred in 1978 and 1979.

Yields

Yield distributions for the crops considered in the risk decision problem were calculated based on three information sources. These included:

a) Time series for the Southern Huila region from the Agriculture Ministry, the Oficina de Planeamiento del Sector Agropecuario (OPSA) (Ministerio de Agricultura [1977, 1973-1977]) and the Region No. 6 ICA office [1977].

b) Results of on-farm bean trials conducted by the CIAT Bean Program Team during 1978 and 1979.

c) Judgmental assessments obtained from the farmers in the bean trials using an instrument to be described in more

detail in Chapter V.

The time series of average yields, nominal and detrended, for the major crops in the region is contained in Table 3.3. For the more established crops and cropping methods, nine years of data are available. For some other crops, such as onions, the figures are merely tentative since no accurate production records exist at the regional or national level. Nevertheless, the yield data shown in Table 3.3 closely correspond with observed means for Southern Huila, with the exception of platano, for which national averages seem higher than the observed means for Southern Huila. In assessing the potential of this data for use in the risk decision model, two problems are suggested. First, the data available for the total of nine years have a pronounced trend, indicating perhaps a change in technology over the period. This trend was removed before calculating the moments of the distribution in order to account for technological changes. The detrending of the yield series was done as follows:

Let $Y_t = \alpha + \beta t + \varepsilon$

where

Y_t = annual yield,

t = time in years.

Then, the detrended yield for year t will be

$$\hat{Y}_t = \hat{\alpha} + \hat{\beta}_t ,$$

where the mean yield for the detrended series, $\hat{\bar{Y}}$, is the same as the reported mean yield $\bar{Y}$. The estimated yield variance is

$$S^2 = \frac{(Y_t - \hat{Y}_t)^2}{n - 2} \leq S_t^2 ,$$

Table 3.3

COLOMBIA, AVERAGE CROP YIELDS, 1971-1979
(KILOGRAMS PER HECTARE)

Year	Corn in Association		Beans in Association		Cassava		Platano[a]		Coffee		Brown Sugar		Tomatoes		Onions
		$\hat{Y}$		$\hat{Y}$		$\hat{Y}$		$\hat{Y}$		$\hat{Y}$		$\hat{Y}$		$\hat{Y}$	
1971	1274	1172.11	624	581.71	8000	7581.57	311	315.07	578	582.33	2497	2505.50	17097	16771	11000
1972	1339	1234.61	597	608.56	8000	7789.55	321	321.47	533	586.99	2702	2650.36	16875	16940	11000
1973	1232	1296.11	620	635.41	8000	7997.53	337	327.87	644	591.64	2701	2795.21	17188	17109	11000
1974	1399	1359.61	648	662.26	8000	8205.51	341	334.27	585	596.3	2830	2940.07	16970	17277	11000
1975	1286	1 22.11	650	689.11	7917	8413.5	350	340.67	651	600.95	3250	3804.93	16765	17446	11000
1976	1294	1484.61	679	715.96	7911	8621.48	322	347.07	619	605.61	3250	3229.79	18000	17615	11000
1977	1484	1547.11	739	742.81	9347	8829.46	340	353.47	571	610.26	3500	3374.64	18000	17784	11000
1978	1500	1609.61	807	769.66	9717	9037.44	372	359.87	608	614.92	3370	3519.50	18000	17953	11000
1979	1991	1672.11	820	796.51			372	366.27							

[a]In bunches per hectare.

Source: FAO, Production Yearbook, 1973-78, Rome. Ministry of Agriculture, Cifras del Sector Agropecuario, Colombia, 1976.

where S_t^2 is the variance of the series before detrending.

Secondly, data series available for the newer bean technologies and the newer crops are restrictive for estimating the covariance matrix which will be necessary for input in the risk decision model. These two factors along with characteristics of the survey data subsequently discussed suggest that caution should be exercised in the interpretation of yield and price series.

Data from the bean trials conducted in Southern Huila are contained in Table 3.4. These data indicate substantially more variation in yields than the time series data. The table contains data for beans grown in association with maize and in monoculture. In making adjustments for beans grown in association and in calculating the final distributions to be employed in the programming model, these data were corroborated with bean production information from corn-beans plots measured on eleven farms in 1979A. The yield measurements were made by the author during the bean and corn harvests in June and September. Moreover, the data from the corn-beans plots are in agreement with similar agro-economic studies (de Londono, Andersen, Sanders and Infante [1978], IDEMA [1978-79]).

Output Prices

As in the case of yields, the objective in this section is to summarize and present the output price series employed in determining the price distributions. The output price series is reported for a 10 year period. In many cases, longer series were available. However, they were thought to be of questionable appropriateness given the possibilities for market and institutional change. Retail and whole-

Table 3.4

CIAT ON-FARM TRIALS YIELDS FOR PLOTS WITH FARMERS' SEED IN MONOCULTURE IN SOUTHERN HUILA, KILOGRAMS PER HECTARE

Year	Mean	Standard Deviation	Coefficient of Variation	n
1978-A	1,561.0	442.3	28.3	13
1979-A	1,535.0	546.0	40.9	29
Farmers' Field 1979-A	Corn : 1,992	102.0	51.2	11
(Corn-Beans)	Beans: 779	263.0	33.8	11

sale prices for the cash crops are widely available and can be regarded as accurately measured and reported. Farm prices for these crops are reported but may differ by time within the semester, location, etc. For this reason, the farm level prices were calibrated with price information obtained by the Bean Program Team in the survey of 50 farms during 1978 and 1979.

For the subsistence crops or those grown for home consumption and limited marketing locally, the price information is much less reliable, if available at all. Retail prices for these commodities can be obtained from IDEMA, the Colombian Institute of Agricultural Marketing [1978-79]. The problem with such prices is that they are from major markets and/or reflective of those received by farmers growing these crops on a commercial basis. They are not in general reflective of the prices in the local markets in which the farmers under study sell their products. One alternative in such circumstances is to use distributions for the prices obtained on a judgmental basis. This is one option subsequently employed.

Input Prices

Input prices were obtained from farmer responses to the Bean Program Team Survey and by elicitation from farm supply dealers. These prices are summarized in Table 3.6. The prices of inputs for the present study are assumed constant. Farmers reported some variation in these prices over time but this appeared to be more due to changes in the nature of the inputs and inflation than inherent price variation. The price of labor fluctuates substantially within the year, largely due to demands at the coffee harvest in the fourth quarter. There is

Table 3.5

REAL PRICES PAID TO PRODUCERS AT THE NATIONAL LEVEL
(PESOS PER TON), 1971-1978 (1978 = 100)

Year	Corn	Beans	Cassava	Brown Sugar	Platano	Coffee	Tomatoes[a]	Onions
1971	8210	39984	6591	6703	5003	47048		
1972	8952	34039	6053	9302	5068	48232	4140	5450
1973	10475	28971	4148	10061	4282	47113	4750	5520
1974	8538	34534	5471	9953	4804	43675	6590	7200
1975	8576	38758	6795	11330	5950	44503	7020	9660
1976	7849	33071	5073	11384	5439	69773	7093	9880
1977	9600	26880	5520	16560	6960	67200	10920	11040
1978	9300	24000	4000	10000	4666	56000	9560	11750

Source: Departamento Nacional de Planeacion, Unidad de Estudios Agrarios, "Series de Precios del Sector Agropecuario, 1950-1976," Documento de Trabajo UEA-DPA-003, Bogota, Colombia, 1978. Based on transformation from the 1970 base year to 1978 using index from Banco de la Republica, Bogota.

Federacion Nacional de Cafeteros de Colombia, Departamento de Mercadeo, "Serie de Precios 1972-77," Productos Agricolas Perecederos Bull. No. 6, Bogota, Colombia, 1978.

Table 3.6

CURRENT PRICES OF SOME SELECTED INPUTS
IN SOUTHERN HUILA, 1978

Item	Unit	Cost Per Unit Pesos[a]
Land Rent	Hectares Per Month	500.0
Labor, Jan.-Sept.	Man Days	150.0
Labor, Oct.-Dec.	Man Days	200.0
Urea, 46% N Content	Kg.	10.0
Fertilizer 10-30-10	Kg.	10.36
Fertilizer 12-12-17-2	Kg.	9.8
Dipterex, granulated, 3%	Kg.	17.3
Parathion 50%	Lt.	119.0
Arazan 75	Kg.	196.0
Methil Parathion 48.5%	Lt.	117.6
Dithane M-22 (MANEB)	Kg.	96.6
Benlate	Kg.	1094.4

[a]1.0 U.S. dollar = 40.0 pesos.

Source: CIAT Bean Team field work, 1978.

evidence of stickiness in labor prices, with a lack of market clearing. This results in excess supplies in some periods and unfilled excess demand, particularly during the planting and coffee harvest seasons.

Production Technologies and Enterprise Budgets

This section deals mainly with a brief description of the more common production technologies for the eight principal crops in the region. The base budgets for each of the home consumption and cash crops are included in the appendix. The number of technologies described is limited to the most common ones. Enterprise budgets are detailed since they will be inputs to a risk programming model.

The budgets are standard in form and report variable production requirements by unit and cost for the important classification of inputs. Prices employed in establishing the variable cost estimates are those received by farmers in 1978.

Coffee

The major cash crop is coffee. Enterprise budgets for coffee are contained in Tables A-3.1 through A-3.2 in the appendix. Table A-3.2 is for old coffee or new *Caturra* coffee grown with low levels of technology. This latter table represents the most prevalent type of coffee in Southern Huila. Old coffee refers to trees of the *Nacional* or *Bourbon* varieties which share the desirable characteristics of longevity and toughness. Such varieties account for most of the coffee grown in the coffee areas of Colombia. The other prominent variety is *Caturra*. Introduced to Huila in the early seventies, this new

variety has accounted for practically all the new plantings since 1973. The Caturra is smaller than the other varieties, thus allowing for higher plant densities. It also has higher production per tree, better response to fertilizer and spraying but has a drawback of significantly lower crop life. While it is very common to find Nacional trees producing for 25 years, the output of Caturra trees decreases substantially after their eighth year and practically stops after the twelfth year.

After planting the trees, until they reach six to nine months of age, little agronomic care is given, especially in the small farms. Two yearly weedings and an occasional pruning and spraying are the usual agronomic practices performed. Spraying and fertilization are limited to the first two years of crop life. After the crop has established a good root system it is left on its own. There are two harvests during the year. The first one is during June and July. The share of total production from the June harvest varies for each climatic zone but for Southern Huila this share is very low, not exceeding ten percent in the old coffee or 25 percent in the Caturra coffee.

The harvest is entirely by hand and limited only to the mature beans. After the picking, the coffee is pitted with a simple hand-powered machine, then fermented for a couple of days to extract the mucilage covering the bean, and then washed. It is then dryed under the sun for several days. Depending on the amount of coffee, the drying is done on top of the ground, in burlap sacks or on cement flats of varying sizes. More sophisticated farmers use metal farmes with large (3x3 meters) drawers which can be put under a tin roof at night. When the coffee is dry it is ready to be sold, usually at the nearest

town.

Coffee can be sold at the Federation of Coffee Producers, a cooperative aimed to market coffee internationally, or to private middlemen. The federation guarantees a fixed (and the highest) price but it also has strict quality control with corresponding price discounts. Middlemen, on the other hand, offer a lower price but do not have quality control or office hours. These middlemen are also sources of informal credit.

Platano

Platano (*Musa sinensis*) is a close relative of the banana and a main staple in the lowland tropics (Purseglove [1972]). It is grown in conjunction with coffee, an association originated by the benefits obtained from shading the coffee trees. Benefits from shading coffee include less soil erosion and pest attack, better weed control, and improvements in bean quality. Furthermore, shading helps old coffee cope with its low light saturation point and thus increase productivity.

Platano is eaten cooked in different forms and it accounts, along with cassava, for the bulk of carbohydrates in the diets. Due to its relative abundance its market value is not as high as implied by the level of consumption. Planting occurs at the beginning of the rainy season with little agronomic care after the crop is established. Since the crop is grown in association with coffee it receives the benefits from the weedings. Farmers harvest platano on a weekly or biweekly basis with most of the crop being consumed at home.

Sugarcane

Sugarcane is a semi-perennial crop normally grown in a three year cycle. It is grown largely for production of brown sugar. The plantings of sugarcane can be anytime during the year except for drought periods. The vegetative material used for the planting is usually selected after an aging period of about two weeks. No further seed treatment is performed. Weeding is the only agronomic practice, with fertilization and pest control virtually non-existent.

Depending on the type of soil and climatic zone the harvest of sugarcane may start at 12 to 24 months of age. Due to the small capacity of the brown sugar mills, harvesting is through progressive cuttings executed every month. Most of the farmers do three complete cuttings before replanting. The mills used in the production of brown sugar may be owned or rented. They are animal powered and inefficient in terms of kilos of brown sugar per ton of sugarcane as compared to other milling methods. Nevertheless, production of brown sugar is an attractive alternative for farmers due to the flexible harvest times and the storability of sugar. The enterprise budget for sugarcane is shown in Table A-3.3. The budget includes the expenses for milling and processing the cane juice into brown sugar since direct sales of cane are uncommon in the region.

Cassava

Cassava (*Manihot esculenta*) is a root crop grown for home consumption and limited scale in local markets. It is a crop with low variable production costs, most of which are associated with labor (Table A-3.4). The culture of cassava is practically identical to

sugarcane up to harvest time. In the case of cassava harvesting occurs once and, depending on the area, may start when the plant is 12 to 18 months of age and continue for up to six months until the crop is totally harvested. The root is eaten cooked or fed to livestock. Also, it can be processed into flour used in the production of some breads. But the latter activity is not important on a large scale basis in Southern Huila. Cassava is generally considered a low risk crop. It has few pests of economic importance and grows well in poor and steeply sloped soils. Furthermore, it has a harvest period long enough to allow the farmer to have a built-in storage capacity for the crop.

As shown in Table A-3.4, cassava is a labor intensive crop par excellence. In fact, as the budget indicates, non-labor costs are practically zero since the five percent share allocated to incidental expenses is associated with the use of machetes, files, and other hand held tools. The almost total dependence on labor and the high biomass yield (around eight tons of cassava per hectare) make this crop especially suited for low income agriculture.

Onions

This is another semi-perennial crop well adapted to Southern Huila's climatic conditions. Production is concentrated around the small towns due to labor requirements. Although easy to grow, onions are considered risky by farmers due to high seasonal price fluctuations. Since reproduction is vegetative, seed price is also subject to wide fluctuations. As a consequence, both production and prices have large variation from season to season. In terms of technology, onions are a

specialized crop. Onion farmers use fertilizer and pesticides on a regular basis. Harvesting is manual with the laborer picking most of the plants on each plant site, leaving two or three stalks to replenish the stock. Harvesting occurs every three months for about five years of crop life.

The budget for onions is detailed in Table A-3.5. Most of the agronomic care is during the first year due to the high cost of establishing the crop. The budget also includes the names and dosages of the most commonly used pesticides. Between the second and fifth year costs of production are somewhat lower due to the absence of seed costs. Yields for the area are around 12 tons per hectare per year.

Tomatoes

Tomatoes are a second specialized crop, requiring different management skills and substantial labor input. As in the case of onions, output prices to the farmer are quite variable within the year. Also, farmers who grow onions and tomatoes tend to do so from year to year. The technology used in growing tomatoes involves a great deal of fertilization and spraying and thus substantial cash expense.

The enterprise budget in Table A-3.6 describes the production technology in detail. Tomatoes are grown in both semesters since they complete their cycle within the semester. The budget included in the appendix is for the first semester. However, production on a continuous basis with plots of different ages is common whether there is a permament source of water. Because of the substantial labor requirements, the majority of producers are located close to the town.

As the budget in Table A-3.6 indicates, tomatoes is a capital intensive crop requiring large cash outlays for the purchase of the support system and pest control. Since tomato farmers are usually skilled in tomato growing, producing tomatoes is not considered as risky as selling them.

Onions and tomatoes are both perishable crops. As explained in a previous section, the perishability of the crops dictates a different marketing structure. Tomato and onion farmers deal mainly with one intermediary. These take the crops directly to large cities for resale in terminal markets.

Corn

Perhaps more than any other crop in Huila, corn tends to be associated with subsistence agriculture. Almost always in association with bush beans, corn is grown primarily for home consumption. Planting starts at the beginning of the rainy season. For the planting the farmer makes a small hole in the ground and buries two to three corn seeds every step (0.75 to one meter) in a haphazard fashion. The resulting plant density is about 27,000 per hectare. No agronomic practices are performed, although the more progressive farmers use hybrid seeds and apply pesticides. Harvesting is manual and the corn is stored in the open, under the roof, until totally consumed.

The budgets for the corn-bean association are shown in Tables A-3.7 to A-3.9. Table A-3.7 corresponds to a cultivation technology which utilizes farm machinery for land preparation and planting, along with the use of a small dose of fertilizer. The technology shown in Table A-3.8, however, is entirely dependent on manual labor and does

not include fertilization or pest control. This is perhaps the most widespread of the three technologies. Finally, Table A-3.9 presents a technology which uses mechanization, fertilizer and pest control. This last technology is used by farmers who have access to both flat land and capital. The three technologies discussed above also differ in their yields. The yields in the budgets are the mean yields reported by the farmers using the respective technology to CIAT's Bean Team personnel.

Beans

Approximately 85 percent of the beans in Southern Huila in 1978 and 1979 were grown in association with corn. Reasons for the association between corn and bush beans are not entirely clear but it seems that farmers want the corn for home consumption and, given their low plant density, use bush beans for ground cover to reduce leaching and erosion. Also, there is evidence that the corn-beans association helps reduce insect attack. Other farmers claim substantial labor savings by the use of the association where the land is too steep for mechanization.

Due to their short growing season beans may be planted twice during the year. The first planting occurs a few days after the corn plantings, at the beginning of the rainy season. The planting is haphazard with a density of about 80,000 plants per hectare. Although farmers perform at least one weeding, weeds still can be a problem. Normally fertilization and spraying are not used, although a few farmers use pesticides on corn or beans or both. Beans are harvested before corn due to the shorter growing season. Harvest is pulling the

whole plant and letting it dry in the sun until the beans reach a water content of 12 to 14 percent.

Once dried, the beans are threshed manually and sold. Beans are usually sold to local middlemen who take them to the retail market or a wholesaler in a middle sized city. This wholesaler in turn sells the surplus from the middle city to a wholesaler in a large city such as Cali or Bogota. Either at the farm or at the warehouse, beans are not stored more than a month due to the potential losses from weevil attack.

Generally, beans are grown in association with corn only during the first semester. The rainy period during the second semester is too short for corn production and therefore beans are grown as a single crop. The cultivation of beans during the second semester is prompted by the farmers' need for good seed necessary for the first semester plantings in the following year.

The budgets for beans grown in association are shown in Tables A-3.7 to A-3.9. Differences in the yields due to technological effects were discussed in the previous section. In cases where beans are machine sown the mean plant density is 200,000 per hectare. Tables A-3.10 and A-3.11 describe the costs of production of beans grown alone. The main differences between the two technologies discussed in the budgets relate to the intensity of labor use and fertilizer and pest control applications, the former technology being much more common than the latter. The more modern technology, however, is more common on medium-sized farms with better access to capital and low sloping land.

Gross Margins for Production Enterprises

This section develops the distribution of gross margins for the principal crops grown in Southern Huila and includes the variance-covariances necessary for specifying the risk programming model. It is assumed that prices and yields are multivariate normal. The mean vectors for prices are calculated from the yearly time series previously discussed. These series were deflated using the appropriate price index from the Banco de la Republica, the Colombian Central Bank.

Since farmers in Huila market their beans immediately after harvest the price spread shown by monthly price series at the national level does not reflect the price variation faced by Huila farmers. Furthermore, the regional (i.e., Southern Huila) monthly price series which would be needed in order to compute the within season variation is non-existent. As a consequence the series used for the computation of the distribution only reflect the between season variation. Similarly, the yield series used in the computation of gross margins is also annual. As in the case of the price series, the series for yield underestimate the within season yield variation faced by farmers.

Tables 3.7 and 3.8 show the mean and standard deviations for the prices and yields just described. Consistent with field observations the coefficients of variation for prices follow the ranking suggested by the farmers interviewed. High price variation, for instance, is associated with tomatoes and onions, both considered risky by farmers. The lowest price variation occurs in coffee, an obvious fact considering that its price is fixed by the government. The coefficients of variation for yields, on the other hand, show only small differences among the crops. This is apparently due to the yearly

Table 3.7

DISTRIBUTION OF REAL PRICES PAID TO PRODUCERS AT THE NATIONAL LEVEL (PESOS PER KILOGRAM), 1964-1978 (1978 = 100)

Crop	Mean	Standard Deviation	Coefficient of Variation
Corn	8.94	8.39	9.4
Beans	32.53	5.58	17.17
Cassava	5.45	1.03	18.9
Brown Sugar	10.66	2.79	26.17
Platano	5.27	0.85	16.13
Coffee	52.94	10.31	19.47
Tomatoes	7.15	2.42	33.85
Onions	7.23	3.57	49.38

Table 3.8

DISTRIBUTION OF REPORTED ANNUAL YIELDS FOR THE PRINCIPAL CROPS IN SOUTHERN HUILA, 1971-1979 (DETRENDED)

Crop	Mean (Kg./Ha.)	Standard Deviation	Coefficient of Variation
Corn (in association)	1422.1	168.86	11.87
Beans (in association)	689.11	35.98	5.22
Cassava	8361.5	534.74	6.39
Coffee (in association)	599.66	38.09	6.35
Platano (in association)	340.66[a]	13.21	3.87
Brown Sugar	3012.50	122.10	4.05
Tomatoes	17361.87	381.34	2.19
Onions	11000.0[b]	--	--

[a]In bunches per hectare.

[b]Yields assumed constant due to absence of time series.

nature of the time series which underestimate the within-season variation.

The variable costs of production used for the computation of the distribution of gross margins are shown in Table 3.9. The cost figures correspond to the model cropping technologies found in the study area. The cost figure for corn-beans may not be as representative as suggested by field observations (see Table A-3.9) but was chosen to be consistent with the gross margins reported by farmers. The variable production cost for coffee is for a crop grown in association under the low technology package (Table A-3.2). The other common crops in the area (cassava, brown sugar, tomatoes, and onions) present cost figures defined in their respective budgets in the appendix. Tables 3.10 and 3.11 present the gross margins series and the distribution of gross margins for the model crops and technologies existing in Southern Huila. In general, the profitability of each crop, as shown in the series of gross margins, is consistent with the field observations obtained by CIAT's Bean Team. The exception is cassava which is indicated as more profitable than observed.

The estimated gross margins are simply the gross revenues (prices times yields) minus the variable costs, labor excluded, while the distribution is assumed to have two moments, calculated from the time series. In terms of the coefficients of variation (Table 3.12), the estimated gross margins from time series seem to be at odds with the field observations. The profits from brown sugar appear higher than indicated by farmers while the coefficient of variation for tomatoes seems to be lower than expected.

The variance-covariance matrix necessary for the risk program-

Table 3.9

VARIABLE COSTS OF PRODUCTION FOR THE MODEL CROPS AND TECHNOLOGIES IN SOUTHERN HUILA, 1978

Crop	Variable Costs
Corn-Beans	9692.0
Cassava	282.0
Brown Sugar	4914.0
Coffee-Platano	6408.0
Tomatoes	62393.0
Onions	17557.0

1.0 U.S. dollar = 40.0 pesos.

Source: CIAT Bean Team field work.

Table 3.10

ESTIMATED GROSS MARGINS FOR THE MODEL CROPS
AND TECHNOLOGIES IN SOUTHERN HUILA

Year	Corn-Beans	Cassava	Brown Sugar	Coffee-Platano	Tomatoes	Onions
1971	23190	52446	11880	44150		
1972	22075	48142	19740	43677		
1973	22293	32902	23209	45600		
1974	24786	43486	24348	43738	123974	29908
1975	29213	53514	30038	53824	91132	21526
1976	25638	39851	31854	63073	84322	44175
1977	25127	51313	50970	67452	129567	19480
1978	23749	38586	30281	60486	73511	83643

Table 3.11

ESTIMATED DISTRIBUTION OF GROSS MARGINS FOR THE MODEL CROPS AND TECHNOLOGIES FOR SOUTHERN HUILA

Crops	Mean	Standard Deviation	Coefficient of Variation
Corn-Beans	24508.9	2299.5	9.38
Cassava	45030.0	7501.9	16.66
Brown Sugar	27790.0	11438.3	41.16
Coffee-Platano	52750.0	9800.4	18.58
Tomatoes	100501.2	24868.7	24.74
Onions	39746.4	26391.4	66.40

Table 3.12

CORRELATION COEFFICIENTS FOR GROSS MARGINS FOR THE MODEL CROPS AND TECHNOLOGIES IN SOUTHERN HUILA[a]

	Corn-Beans	Cassava	Brown Sugar	Coffee-Platano	Tomatoes	Onions
Corn-Beans	1.0 (0.0)	0.430 (0.287)	0.420 (0.299)	0.422 (0.296)	-0.08389 (0.8933)	-0.58879 (0.2962)
Cassava		1.0 (0.0)	0.075 (0.858)	0.013 (0.975)	0.484 (0.408)	-0.804 (0.100)
Brown Sugar			1.0 (0.0)	0.864 (0.005)	0.433 (0.465)	-0.325 (0.593)
Coffee-Platano				1.0 (0.0)	-0.135 (0.765)	0.160 (0.796)
Tomatoes					1.0 (0.0)	-0.725 (0.165)
Onions						1.0 (0.0)

[a]Numbers in parentheses are the probability levels for H_0: $\rho = 0$.

ming model is based on the variances obtained from Table 3.11 and the coefficients of correlation obtained from the series of Table 3.10. The correlation coefficients for the major crops in Huila are shown in Table 3.12. As the correlation coefficients indicate, negative relationships among the different gross margins exist only for tomatoes and onions and the group of the other crops. This in turn indicates a trade-off in profits between the presence or absence of risk in crop production since tomatoes and onions are considered risky crops. Caution should be exercised, however, in the interpretation of some of the elements of the correlation matrix as the correlation coefficients in several cases are not statistically significant from zero. The variance-covariance matrix (Table 3.13) is computed from the formula

$$\mathrm{cov}(j, j') = \rho\sigma_j\sigma_{j'} ,$$

where ρ is the correlation coefficients between j and j' and σ_j, $\sigma_{j'}$ the corresponding standard deviations. The resulting calculations are broadly consistent with field observations in terms of signs and relative magnitudes. As discussed earlier, tomatoes and onions are grown in monoculture and, generally, not on diversified farm plans. The variance-covariance matrix shown in Table 3.13 is later expanded to include all the technologies in the programming model.

Conclusion

Difficulties associated with the time series data for prices and yields are numerous. Prices present problems of aggregation. In the case of more commercial crops such as beans or brown sugar the

Table 3.13

ESTIMATED VARIANCE-COVARIANCE MATRIX FOR GROSS MARGINS FOR THE MODEL CROPS AND TECHNOLOGIES IN SOUTHERN HUILA

	Corn-Beans	Cassava	Brown Sugar	Coffee-Platano	Tomatoes	Onions
Corn-Beans	5287612.0	7419140.0	11053262.0	9526990.0	-4797261.0	-35731640.0
Cassava		56279349.0	6492383.0	969754.0	90334303.0	159330259.0
Brown Sugar			130835800.0	96866731.0	123366172.0	-98244969.0
Coffee-Platano				96047182.0	45088670.0	41471232.0
Tomatoes					618453096.0	-476429791.0
Onions						696507012.0

prices reported are only monthly averages. In the case of subsistence crops such as platano or cassava, the observed prices are the monthly averages obtained for marketed surpluses of those subsistence crops. As a consequence, the use of price series as a means of estimating price risk seems inadequate.

Similarly, a major problem with yields is the aggregate nature of yield estimates. Crop yields are aggregated both across farms and across geographical regions, thus producing a downward bias in the variance estimates. Moreover, the reported aggregate yields mix the different crop technologies utilized, differences in resource quality, and climatic differences. Accounting for the above factors is highly desirable in a small farming environment since their influence can not be "averaged-out" over time. Finally, the yields reported in the time series are many times the best "guesstimates" from extension agents (Villaroel). Although their estimates are well founded they undoubtedly possess qualitative differences which translate into problems of data accuracy.

FOOTNOTES

CHAPTER III

[1]The definition of small farmer used here is that of an individual whose income comes primarily from farming and who is engaged in semi-subsistence farming with most of his production destined for on-farm consumption. Farm production takes place on a holding which is small relative to other farms in the area and with technologies which are mostly labor intensive. For a thorough discussion on the subject see: Pedro Patricio Crespo, "Small Farms, Credit, and Technology Adoption: An Analysis of the Semi-Arid Region in Northeast Brazil," M.S. thesis, University of Missouri-Columbia, 1978.

[2]The effect of tight credit has been studied in other areas of Colombia with similar characteristics to Southern Huila. The Caqueza Project, a small farm development project in Eastern Cundinamarca, Colombia, has identified four basic credit sources. institutions, relatives, friends and merchants. Only one-third of farm loans came from institutional sources and one-tenth from merchants. This leaves friends and relatives as the main sources of capital. For a detailed discussion see: H. Zandstra, K. Swanberg, C. Zulberti, and B. Nestel, Caqueza: Experiencias en Desarrollo Rural, CIID, Bogota, Colombia, 1979.

CHAPTER IV

THE RISK PROGRAMMING MODEL

Introduction

The purpose of this chapter is the review of the theoretical framework for the farm risk problem. It begins with a conceptual statement on risk and then evolves into a more formal framework for farm planning under conditions of price and yield uncertainty. In addition, the chapter addresses the logistics of building a programming tableau to include new technologies in the form of added activities. As well, changes in the institutional framework involving new activities or modifications in the objective function are considered.

Risks in producer and consumer decision problems have become a subject of increased interest in agricultural economics. Choices, implying judgments about alternative subjective probability distributions of outcomes, are common for agricultural decision units. Factors affected include the choice of technique and/or the adoption of new technologies. For decision makers with low income levels, the implications of uncertainty for farm decisions may be especially important.

A variety of approaches for handling risk in the firm decision model have been advocated (Anderson, Dillon and Hardaker [1977]). Of these, the expected utility approach appears most plausible and tractable for applied work. Furthermore, the decision theory based on the maximization of expected utility is normatively coherent and represents

a complete basis for choice in uncertain circumstances, making the results especially well suited for policy analysis.

The present analysis of the farmer's decision making process is based on the expected utility framework. The framework presumes that a utility function exists for a decision-maker whose preferences are consistent with a prespecified set of axioms on ordering, continuity and independence. Each decision maker's preference is based on a subjective probability distribution over all risky alternatives. Thus, the utility function simply assigns values to a set of consequences. This index is used to maximize subjective expected utility (Borch [1968], Dillon [1971], von Neumann and Morgenstern [1947]).

Throughout the study a quadratic functional form for utility is assumed. This assumption greatly simplifies the analysis since it implies that only a two-parameter density for portraying the uncertain options, a simple mean and variance. The use of functional forms in only the mean-variance space has created substantial controversy (Feldstein [1969], Hanoch and Levy [1969], Roumasset [1976], Tobin [1969]). The mean-variance space is appropriate only if one or both,

a) the utility function is quadratic,

b) the random variables are normally distributed.

Obviously, it is not clear whether or not such conditions hold in the empirical world. However, the use of quadratic utility functions is appealing for its convenience. It is monotonically increasing over a restricted range and has positive marginal utility, since it is also nondecreasing. Hence, if the utility function is assumed dependent upon two moments, the mean and the variance, then the decision maker's trade-off or rate of substitution between mean and variance while

keeping a constant level of utility becomes intuitively obvious: a risk averse individual will need to increment the value of the mean to compensate for increased variance.

Farm Planning Under Uncertainty

The applied framework for planning a farm under uncertainty is a specialization of the Markowitz portfolio problem (Markowitz [1959]). Specifically, let e_i equal expected net return per hectare for farm enterprise i, i = 1, 2, ..., n; σ_{ii} the variance of net returns per hectare for farm enterprise i; σ_i the standard deviation of net returns per hectare for farm enterprise i; σ_{ij} the covariance of net returns per hectare between farm enterprises i and j; ρ_{ij} the correlation coefficient of net returns per hectare between farm enterprises i and j; Z, the fixed asset available; X_i, units of fixed asset allocated to farm enterprise i; and Y be total income. Then a farm composed of n crop enterprises will have an expected net return of,

$$E = \sum_{i=1}^{n} X_i e_i$$

and a variance of net returns

$$V = \sum_{i=1}^{n} \sum_{j=1}^{n} \rho_{ij}\sigma_i\sigma_j X_i X_j \ .$$

Under the above conditions the optimum combination of enterprises may be derived as follows. Let AB be the locus of points where, given a variance of income the value of net returns E is at maximum (Figure 4.1).

Each point in AB would then represent a combination of crops

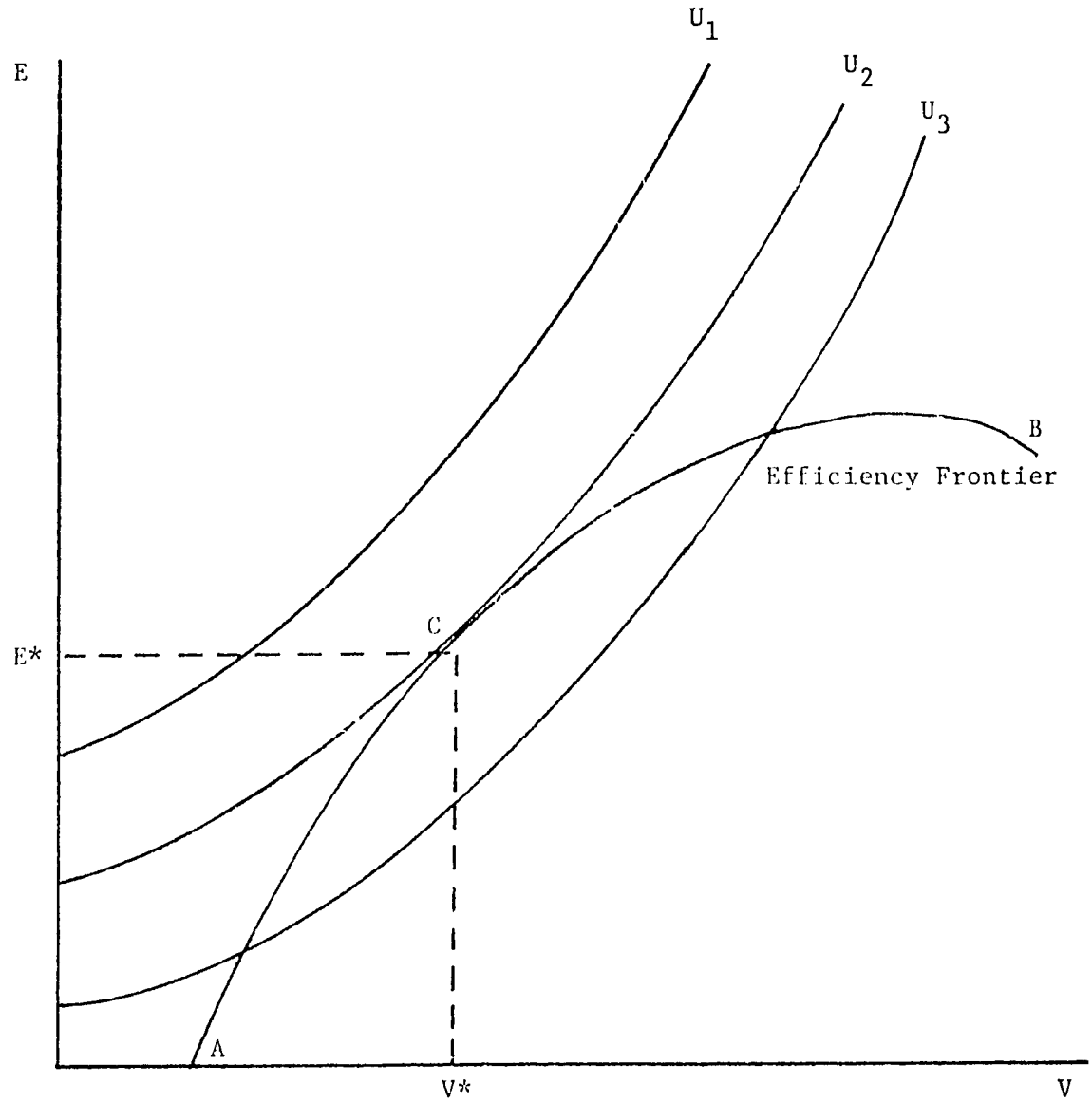

Figure 4.1. An optimal farm plan under risk aversion.

which yield the largest profit for a given profit variance. This locus of points AB is called the efficiency locus in the mean-variance space. If the utility contours are of the form u_1, u_2, u_3, then C in Figure 4.1 is the point where a risk averse farmer would attain the highest level of utility from the crop combinations. For utility quadratic, finding point C is a quadratic programming problem where the X_i are to be allocated to maximize

$$U(y) = E + bV$$

$$= \Sigma X_i e_i + b\Sigma\Sigma\rho_{ij}\sigma_i\sigma_j X_i X_j$$

subject to

$$X_i \geq 0$$

$$b < 0$$

and

$$\Sigma X_i \leq Z .$$

This is equivalent to the maximization of an objective function which includes linear and quadratic terms subject to a set of linear inequality constraints. Specifically, the problem to be solved is of the form: Find the vector $\underline{X}$ which maximizes

$$f(\underline{X}) = \underline{c}\underline{X} + \underline{X}'Q\underline{X}$$

subject to

$$A\underline{X} \leq \underline{b}$$

$$\underline{X} \geq 0 ,$$

where $\underline{c}$ is (1xn) vector of constants; $\underline{X}$ is an (nx1) vector of activi-

ties; Q is a symmetric positive semidefinite covariance matrix, A is an (mxn) coefficient matrix, and $\underline{b}$ an (mx1) vector of resource constraints. Since $\underline{c}'\underline{X}$ is linear and $\underline{X}'Q\underline{X} \geq 0$, the objective function is a convex function and the Kuhn-Tucker conditions are necessary and sufficient for a maximum (Sposito [1975]).

Risk Programming

Two approaches can be employed in applying the quadratic programming to risk decision problems. The first and most simple is to apply the method to parametrically trace-out the efficiency locus (Markowitz [1952]). The efficiency locus identifies combinations of enterprises which minimize the variance of returns subject to feasible mean return levels. This method has been long recognized and applied in studying the implications of farm diversification (Johnson [1967]). This problem is solved using the quadratic programming algorithm by reformulating the problem as

$$\text{Max } \underline{cX} + X'Q\underline{X}$$

subject to

$$A\underline{X} \leq b$$

$$\underline{cX} = \alpha$$

$$\underline{X} \geq 0 ,$$

where α is a predetermined income level and $\underline{c}$ the vector of mean gross margins for the individual enterprises. By parametrically varying α, the efficiency locus can be determined (Freund [1956]).

A second version of the risk programming problem provides for the inclusion of a risk aversion coefficient. The quadratic programming

problem for this case is similar to that for the efficiency locus formulation

$$\max_{\underline{X}} \underline{CX} + \phi(\underline{X}'QX)$$

subject to

$$A\underline{X} \leq b$$

$$\underline{X} \geq 0 ,$$

where the scaler ϕ multiplied by the variance term in the objective function is a weight depicting the decision maker's aversion or preference for risk.

For the weight of zero, the problem solves for the combination of enterprises maximizing expected profits. Weights less than zero indicate risk aversion. Obviously, such weights would move the quadratic programming solution away from the expected profit maximizing solution if farm diversification results in diminished variance of net returns and/or the lower income enterprises have lower variances.

Risk and the Adoption of New Bean Technology

The optimization model, when estimated values for ϕ are included in the objective function, is taken to provide a more realistic picture of optimum farm diversification. If this is the case, the inclusion of new activities representing new crop technologies should yield a useful *ex ante* evaluation of their impact on farm income and resource employment.

The new activities introduced into the programming model are the Better Agronomy technologies, as generated by the CIAT on-farm

technology trials (see Chapter II). Relevant questions to be answered are:

a) The magnitude of the influence risk exerts on both the decision to adopt and the level of adoption of new bean technology.

b) The sensitivity of farm income to changes in risk aversion.

c) The sensitivity of farm income to variability in new technology yields.

d) The sensitivity of farm income to changes in the expected yields for new bean technologies.

Answers to these questions are useful in assessing the importance of each production factor on technology adoption and for new technology redesign.

Institutional Factors: Storage and Marketing Boards

A major hypothesis of this study of bean technology and adoption relates to the controllability of institutional factors. Specifically, the adoption process is influenced by institutional factors which themselves can be altered. Thus, when adoption rates are low, two policy options are available. First, investment can be made in developing new technologies more consistent and appealing given the present situation. This would appear to be the dominant strategy taken in international technology development institutes such as CIAT. A second alternative concerns the institutional factors which govern the environment of the farmer. It is possible that some aspects of this institutional environment can be altered at low economic and political

cost. These options have in general received little attention by the agencies devoted to technology development and adoption.

An important purpose of the present study is to show how the decision making model developed to analyze adoption can be employed to study the implications of institutional change. Two types of institutional change, albeit broadly viewed, have been selected for analysis. Both have implications for the prices at which farmers buy and sell beans. The first is storage. Presently, little on or off farm (controlled by farmers) storage of beans exists. Various factors have contributed to this situation but the major one is the bean weevil. Methods for controlling this insect have now been developed and applied in an on farm context (Schoonhoven [1976], Bowman [1979]). Thus, storage is a technically feasible activity in which farmers can engage as a basis for changing the price received for output and the price of beans purchased for home consumption and seeds.

The institutional aspect of an on-farm storage program relies heavily on financial support and the technology transfer process. Financial support is necessary for the purchase of the additional inputs necessary for storage, and for income necessary during the storage period. In terms of technology transfer the support from the present institutions may come from the extension service by means of demonstrations and technical advice.

It is assumed that beans stored on the farm can be kept for six months without incurring price discounts in the consumption or seed markets. The experience with the on-farm trials in Southern Huila would indicate that losses are less than two percent for the six month period and that the assumption for the price of stored and non-stored

beans is appropriate.

The second alternative for institutional change is a marketing board or organization designed for price stabilization. The apparent stable demand for beans in major urban markets together with a highly fluctuating price and supply in local markets suggests substantial local demand inelasticity. By providing for a more orderly marketing process (perhaps including storage), supplies to local markets can be smoothed or the capacity of the markets expanded. Thus, marketing boards can serve to stabilize price and perhaps increase farmers' incomes from beans.

There is ample cursory evidence that the marketing process for beans does not operate to the small farmer's advantage. Sales to middlemen are in the village market. No on-farm or village level storage exists and transportation to markets which are less thin and serve wider distribution areas is apparently not systematically arranged. Farmers thus harvest their beans and sell them in the village market almost immediately. Supplies to the village market are difficult to predict and prices fluctuate substantially in response to the level of supply. But farmers, since they frequently carry their beans to market, do not wish to incur the cost of carrying them back home (and would not have a place to store them in any case) and therefore are effectively restricted to taking the existing price.

Marketing organizations could contribute to the farm incomes by (a) communication of selling prices, bean supplies and market capacity, (b) coordination of harvest and planting to smooth supply, (c) arranging closer ties with less thin markets through improved and more responsive transportation, and (d) the provision of storage. Two

organizational options exist for these marketing boards. The first and most feasible is a cooperative. But in Huila, the cooperative form of board would be difficult to organize and could impose conditions upon the farmers restricting participation.[1] The coffee marketing board is an example of such an organization. Because of the lack of concentration of bean production and the smallness of the holders producing the majority of the beans, this form of organization has not been utilized in work with other commodities coming from the peasant farms.

A second form of organization is an "association". Associations have been set up in the Southern Huila area for processing brown sugar. The associations are loosely organized and provide a facility which the farmers can rent at a cost based price for processing sugarcane close to their home community. Subsidized loans are available for assisting the farmers in provisioning the facilities to support the association activities. For example, CARE and ICA have supported this approach through their involvement in sugar processing. Loans are typically made for materials, equipment and the skilled labor necessary for constructing the facilities, with the interested farmers through the association, making available unskilled labor. The facilities can be constructed during periods when the opportunity cost for unskilled labor is low. Inducements to supply such labor can be arranged by linking the amount to the priority for using the facility.

Specific questions asked of the programming model are:

a) How much price variability would the association have to have to affect to make it a profitable undertaking for the farmers?

b) What would the association have to do to prices in terms of levels and variability to induce the adoption of the new technologies?

c) What would be the likely supply response to the association?

The Empirical Model

The model is a one-year tableau representing the predominant set of present and selected potential farming activites in Southern Huila.[2] Corn, beans and tomatoes are the only semestral activities and therefore two plantings per year are permitted. Since water is in shorter supply during the second half of the year, expected yield adjustments have been made. Coffee, plantains, cassava, onions, and sugarcane are the other common crops. Since their economic life is longer than one year, their cost and income streams have been brought to the present as annuities.[3]

All capital is generated on a short-term basis. The operating capital for each activity can come from loans, labor sales or activity sales. Loans are initiated at the beginning of the first and third quarters and paid back at the end of the second and fourth quarters, respectively. Farmers may borrow from private sources, public institutions, or both. Although the institutional rate of interest is lower than the private rate, the transaction costs associated with institutional loans may be higher than the cost of borrowing from friends or middlemen. Consequently, both sources are assumed to be lent at the same rate.[4]

Loans from private sources are unrestricted for within farm

allocation. Institutional loans, however, have minimum and maximum amounts allocated to each particular crop, as prescribed by government policy. Capital restrictions are introduced through adjustments in the total borrowing capacity of the farm and through specifications on sources of capital. The specifications for total borrowing capacity are based upon levels reported by farmers. The institutional capital is available but there are restrictions on crop choice. Informal capital when available is not pegged to particular crops. The model has been adapted to simulate restrictions on capital coming from both institutional and informal sources.

Labor requirements of permanent crops are not discounted. Labor requirements in the model are an average of the quarterly labor requirements for all the years of crop life. Labor is restricted to reflect seasonal peaks in demand and, primarily, management capacity. The value for the hired labor constraint was derived from farm interviews. Family labor can be utilized on the farm at zero cost or sold at the prevailing wage rate. The product prices used in the model are an average of the prices reported by farmers during 1978, the year of the interviews. The price of beans after storage is based on the price obtained at the end of the storage period. Throughout the study 1978 is considered the base year.

Farm Types

The model was divided into two predominant bean farm types by size (ICA [1978]). Previous studies by ICA have identified approximately sixty-one cropping systems in Southern Huila (Table 4.1). The largest group (Farm 1) is fairly diversified producing principally

Table 4.1

COMMON FARM TECHNOLOGIES IN SOUTHERN HUILA

Crop	Labor Intensive	Machinery[a] Labor Combination	Use of Fertilizer	Use of Pesticide	Storage	Average Yields (Kg. Per Ha.)
Caturra Coffee	x		x	x	x	1,215
Caturra Coffee Low Technology	x		x[e]	x[e]	x	466
Old Coffee	x				x	375
Sugarcane	x				x[b]	3,370
Sugarcane		x			x[b]	3,370
Cassava[f]	x				x[c]	4,400
Tomatoes	x	x	x	x		16,305
Onions	x		x	x		11,000
Beans	x					860
Beans		x				860
Beans		x	x	x		1,270
Beans	x			x		1,118
Corn-Beans	x			x		800[g] 500[h]
Corn-Beans		x		x	x[d]	1,875[g] 800[h]
"Platano" (bunches of approximately 12 kg. each)	x		x	x		552

[a]The use of machinery is restricted to land preparation and planting.

[b]In the form of brown sugar.

[c]Storage is achieved by leaving the crop unharvested up to six months after maturity.

[d]Storage for corn.

[e]For the first two years of crop life only.

[f]Yields for permanent crops have been brought to the present.

[g]Corn.

[h]Beans.

Source: Bean Team field work and Instituto Colombiano Agropecuario (ICA), Districo de Transferencia de Tecnologia Sur del Huila, Diagnostico Distrital, Regional 6, Ibague, Colombia, 1978.

coffee-platano, corn-beans, pastures, and small amounts of other food crops. The second group (Farm 2) concentrates on tomatoes and onions. Sophisticated production and marketing knowledge are necessary to produce the latter crops. Farm type 3 has a cultivation pattern similar to that for the first group with larger areas in sugarcane, beans, and pasture.

Income levels from the two types of small farms are approximately equal (see Table 4.2). However, large differences do exist in the use of hired labor and operating capital (Table 4.3). Tomato-onion producers use relatively large amounts of hired labor during the second quarter, for the tomato harvest, and large amounts of operating capital. The other farm types have a more uniform labor pattern and lower levels of operating capital.

Equivalent earnings to the Farm 1 are earned by Farm 2 in shorter time period but with greater risk given the cash expenditures required and the dependence upon hired labor. Finally, the labor sales on Farm 1 can be absorbed by the labor purchased on Farm 3 indicating an important complementarity or interdependence between farms by size.

Summary

The model described is perhaps the simplest one incorporating risk. Risk is considered only in relation to the objective function, leaving the constraints fixed. This assumption will be subsequently relaxed in the sensitivity analysis. The model structure follows the specification of the one-period linear programming tableau, as depicted in Beneke abd Winterbaer [1972], with the quadratic term added to the objective function to incorporate risk. The new CIAT bean technology,

Table 4.2

TYPICAL FARM PLANS FOR BEAN FARMS OF TWO SIZES AND ONE SPECIALIZED VEGETABLE FARM IN SOUTHERN HUILA[a]

Item	Small Farm 1 2.4 Hectares	Small Farm 2 2.4 Hectares	Medium Farm 15.8 Hectares
Gross Margin With Labor Sales (Pesos)	76,795.87	79,462.12	182,380.5
Gross Margin Without Labor Sales (Pesos)	58,448.87	55,562.12	182,380.5
Low Technology Caturra Coffee	1.0	--	2.0
Old Coffee	--	--	1.0
Sugarcane	--	--	3.0
Cassava	0.25	--	1.0
Tomatoes	0.01	1.65	--
Onions	0.05	0.25	--
Beans	--	--	1.50
Corn-Beans	0.50	--	0.50
Pasture	0.55	0.50	6.80

[a]Without soil problems.

Source: Instituto Colombiano Agropecuario (ICA), Districo de Transferencia de Tecnologia Sur del Huila, Diagnostico Distrital, Regional 6, Ibague, Colombia, 1978. Ruiz N. de Londono, Per Pinstrup Andersen, and M. Infante, "Estudio Agroeconomico de los Procesos de Produccion de Frijol (Phaseolus Vulgaris) en Colombia," CIAT, Cali, Colombia, 1978.

Table 4.3

LABOR USE AND CAPITAL UTILIZATION FOR THREE TYPICAL FARMS IN SOUTHERN HUILA

Variable	Small Farm 1 2.4 Hectares	Small Farm 2 2.4 Hectares	Medium Farm 15.8 Hectares
Total Labor Use (Man Days Per Quarter)			
First	41	89	195
Second	51	434	151
Third	20	5	129
Fourth	36	5	171
Hired Labor[a] (Man Days Per Quarter)			
First	-24	24	130
Second	-15	369	86
Third	-45	-60[b]	64
Fourth	-29	-60	106
Operating Expenses	9,333	166,325	104,388
Borrowing	9,333	107,337	41,423

[a]A negative sign indicates net labor sales.

[b]Tomato farmers usually plant once a year and hence have idle family labor during the last two quarters. Farmers who plant next to a secure water source may plant twice a year.

Better Agronomy, and the changed institution, on-farm storage, are incorporated in the model as new activities in the tableau. Marketing board, the other institutional change, is incorporated by varying characteristics of the price structure.

FOOTNOTES

CHAPTER IV

[1]In Southern Huila only eight percent of the farmers belong to a cooperative and of those, only one-third are very interested. See ICA [1978].

[2]The variable code in in Appendix D.

[3]The discount rate used in the procedure is 10 percent. See A. Harberger, Project Evaluation, (Chicago: University of Chicago Press, 1972), Chapter VI.

[4]Some empirical support of this treatment of credit is found in H. Zandstra, H. Swanberg, C. Zulberti, and B. Nestel, Caqueza, Experiencias en Desarrollo Rural, CIID, Bogota, Colombia, 1979.

CHAPTER V

RISK ATTITUDES, JUDGMENTAL DISTRIBUTIONS, AND SPECIALIZATION OF THE RISK PROGRAMMING MODEL

Introduction

This chapter deals with the specialized methods utilized to incorporate the effects of risk aversion on the small farm system. Firstly, it details the method and results of the assessment of risk aversion attitudes among the target farmers. This is necessary to establish the magnitude of the risk coefficient included in the risk programming model.

The assessment is based on Dillon and Scandizzo's procurement methods as applied to Northeast Brazil with slight modifications with respect to the size of the bets and the use of one lone interviewer to minimize the associated bias. This latter aspect has been found to be a problem on related risk aversion measurements taken on peasant farmers in alternative contexts (Dillon and Scandizzo [1978], Binswanger, Jodha and Barah [1979], Binswanger [1979]).

Secondly, farmers' perceptions of price and yield uncertainty are measured and analyzed. This approach used is in response to the problem of data quality for this and most of the developing areas. Since time series for prices and yields found in the developing countries are often of poor quality or of an excessively aggregate nature it is hypothesized that substitution for the time series variance the farmers' subjective assessment of price and yield dispersion will give

substantial gains in model performance. The methods employed in the procurement of the subjective measures of variance are complementary to the methods used in the assessment of risk. Finally, to establish the levels of yield and price variation, it was necessary to determine the levels of yields and prices actually obtained by farmers. These figures were then used as frame of reference in the calculation of farm income, a necessary step in the assessment of risk aversion.

The chapter is organized as follows: First, the concept of risk aversion and the estimation methods used in this study are discussed. Second, the interview data and the main findings are respectively described and analyzed, with emphasis on the effect of socioeconomic factors on risk aversion. A third section reviews the method of obtaining judgmental variances. This is followed by a discussion of the results for the elicited judgmental distributions for prices and yields. Finally, the last sections discuss the computation of the judgmental covariances and an evaluation of the results.

Risk Aversion

Two approaches to the measurement of risk attitudes have been used. The first is implicit. The quadratic programming model can be formulated for the specific farms surveyed. From survey records the combination of enterprises that the farmer has selected in the past is known. A value of the risk aversion coefficient can then be determined such that the enterprise combination selected was in fact optimal. This value is then the implicit estimate of risk aversion coefficient for the farm.

The main drawback for the implicitly obtained coefficients is that the information is dependent upon accurately representing a deci-

sion situation which is likely very complex. Hence, the relevance of this information for farm decision making is questionable. At best, the implicit risk aversion coefficient can serve as a consistency check on coefficients obtained from other procurement methods.

The second approach to risk measurement involves the use of synthetic experiences (gambles or games) in which, through a sequence of choices, the attitude towards risk is ascertained. This "experimental measurement" approach has been increasingly applied in studying farmer decision processes within developing countries (Binswanger [1978], Benito [1976]). Respondents can be classified as risk neutral, risk averse or risk takers by examining the results of the experiments relative to the corresponding certainty equivalent without reference to the utility function (Binswanger, Jodha and Barah [1979]). However, a quadratic functional form for utility must be assumed if a quantitative result is to be obtained for inclusion in a risk programming model.

The method employed to determine the value of the risk aversion coefficient is similar to that applied by Dillon and Scandizzo in Northeast Brazil. Differences relate to:

a) the fact that all the questions were administered by an individual familiar with the way in which the method is applied to determine the risk aversion coefficient, thus greatly reducing interview bias, and

b) the fact that a risk aversion coefficient was determined for two different types of experiments, each associated with different stakes.

The object of the latter exercise was to provide information on the

constancy of the risk aversion coefficient across larger chances, in the Bernoullian tradition.

The two experiments administered to the farmers are described in more detail in Appendix B. The first experiment involved the use of coins. Pretest of the schedule with farmers indicated that they found it attractive to participate in experiments that involved physical objects. For this experiment, three piles of coins were used. The farmer was asked to choose between one pile that was to be received with certainty and two piles that were to be received with a probability of 0.5 each. The probability level was communicated by indicating that the farmer was to receive one or the other of the latter two piles of coins depending on the outcome of a coin toss. Depending on the choice made, the pile of coins to be received with certainty was reduced or increased until a point of indifference was obtained.

The second experiment involved the choice between two hypothetical, but more realistic options. The first option was one in which the farmer received a certain amount of cash in excess of that required for the family to subsist. This amount was tailored to each farmer depending on actual needs. The second option was one which in three of four years gave a higher return than the necessary to sustain the family. However, for one of four years this amount was considerably smaller than the amount received with certainty. The farmer was asked to choose between the options and then the certain option was adjusted upward or downward based on the responses until a point of indifference was found.

A variant of this last experiment was also performed. Farmers were asked about their preferences using cash options significantly

lower than in the second experiment but with the farmer's subsistence assured. This variant was deemed useful for assessing the constancy of risk aversion to different payoff levels.

The points of indifference obtained from each experiment were employed to calculate a coefficient of risk aversion. In broad terms this was done as follows: Let Q_E be the value of the certain option. Given the quadratic utility assumption, the implied risk aversion coefficient is determined by solving the equation

$$Q_E = \overline{X} + rV$$

or

$$r = \frac{Q_E - \overline{X}}{V}$$

where $\overline{X}$ represents the mean returns, V is the level of variation and r is the risk coefficient. Clearly, if the certainty equivalent is less than the mean, the farmer will be risk averse.

Risk Aversion in a Small Farm Context

Only a few studies exist on the socioeconomic characteristics affecting risk aversion. Moreover, the two main experimental procedures used (betting and income gambles) have failed to provide an empirical base for risk aversion prediction based upon socioeconomic variables. Reasons given for this failure fall into the categories of interview bias and/or "one-period money" effects (Binswanger [1978], Roumasset, Boussard and Singh [1978], Masson [1972]). The elicitation methods for Southern Huila were expected to account for the former problem by utilizing a single interviewer with knowledge on the subject of risk aversion. The latter problem, inherent in gambles of this

nature, cannot be entirely avoided. Gamble results are biased in the sense that the degree of risk aversion is directly related to the degree of imperfection in the capital market. The bias will be more proncunced if the gamble operates on a range where the farmer does not need to either borrow or lend to attain such income (Masson [1972]). Under the above rules it is clear that only the coins game falls into this area. The income gambles proposed to the farmer under the Dillon and Scandizzo method were tailored to the specific income needs of each farmer interviewed. Such incomes did include borrowing and/or lending capabilities and are therefore excluded from "one-period money" bias. The use of both methods, coin games and income gambles, then becomes useful for a consistency check of risk aversion.

Interview Data and Results

The farmers interviewed were selected from among the participants in the CIAT on-farm trials and among farmers receiving technical assistance from the ICA Regional 6 office. While the sample was not random, effort was made to interview farmers who were fairly representative for the area. As a consequence, the characteristics of the sample population closely resemble the regional averages (Table 5.1).[1]

The farmers' willingness to play the interview games was not a problem since they were acquainted with the questioner through the on-farm trials. In general, farmers reacted more seriously to the income gambles than toward the coin game. This was probably due to the more realistic nature of the risky income situation.

The estimated risk aversion coefficients are summarized in Table 5.2. As the table indicates, farmers may have had problems in

Table 5.1

DISTRIBUTION OF SOCIOECONOMIC CHARACTERISTICS FOR ALL FARMERS INTERVIEWED

Variable	N	Mean	Standard Deviation	Coefficient of Variation
Age	30	41.96 years	12.14	28.94
Education	30	2.93 years	2.58	88.14
Children	30	4.00	2.82	70.71
Adults	30	2.86	2.04	71.39
Off-Farm Work (Percent of Total Income)	30	5.25	12.37	235.50
Farm Size	30	7.30 hectares	6.56	89.96
Wealth	30	708600.00 pesos	654040.10	92.30
Experience	30	14.53 years	10.06	69.27
Gambling Expenditures	30	132.66 pesos per month	379.81	286.29
Income Per Year	30	88010 pesos	76836	87.30

Table 5.2

RISK COEFFICIENTS FOR SMALL FARMERS
IN SOUTHERN HUILA

Type of Gamble[a]	n	Mean ϕ	s^2_ϕ	Coefficient of Variation
Consistent Farmers[b]				
Coin Game	18	-0.30	0.84	-272.53
Subsistence at Risk	17	-0.49	0.59	-120.14
Subsistence Assured	17	-0.05	0.51	-881.25
All Farmers[c]				
Coin Game	30	-0.32	0.76	-233.83
Subsistence at Risk	29	-0.32	0.54	-167.35
Subsistence Assured	29	-0.44	0.68	-155.25

[a]For a detailed explanation of each gamble see Appendix B.

[b]The coefficients for subsistence at risk and subsistence assured are significantly different at the 0.001 level.

[c]The three coefficients are not significantly different from each other.

conceptualizing the nature of the gambles. Not only are the coefficients spread over a wide interval but about half of the farmers interviewed showed some degree of inconsistency between the games. The degree of risk aversion when the game included uncertainties for family sustenance was, for approximately half the farmers, lower than risk aversion under assured subsistence. It is suspected that inconsistent farmers either did not understand the gambles or were not internally consistent because of the strongly monetary nature of the questions, a fact that seems to be a problem for semi-subsistence farmers not used to assigning monetary values to their farming activities.

Nevertheless, the results from Table 5.2 are clear. Southern Huila small farmers are risk averse, especially when their sustenance is uncertain. Assuming assured subsistence the farmers interviewed show a mean value of $\phi = -0.05$ for their coefficient of risk aversion, a value similar to what Dillon and Scandizzo have calculated for Northeast Brazil in an approximate context. When subsistence is at risk the value of ϕ increases to $\phi = -0.49$, a value somewhat lower than the $\phi = -1$ found by Dillon and Scandizzo under similar circumstances.

Differences in the magnitude of the risk coefficient attributable to each methodology were found significant between the two income-subsistence games. In addition, no difference was found between the coins game and the game of subsistence at risk. Nevertheless, the lack of a statistical difference in the latter case does not indicate that the coin game, a simple elicitation method, may be used as a substitute for the subsistence at risk game. The theoretical limitations imposed by capital market imperfections are a precluding factor, plus the fact that the game produces a risk coefficient of little significance in

terms of relationships with the socioeconomic environment, as seen in the following section.

Risk Aversion and the Socio-economic Environment

Once the risk aversion coefficients have been obtained two related questions must be answered. The first is which of the coefficients yields a more appropriate estimate of the true level of risk aversion? The second relates to the importance of the risk coefficient for farming decision. That is, what role does such coefficient play in farm planning? The first question may be answered by relating the risk coefficients to the socioeconomic circumstances associated with them and selecting the one explained more adequately.

The effect of socioeconomic characteristics on risk aversion is shown in Table 5.3. Of the three OLS regressions shown in the table the equation for the coin game offers the least explanatory power. Given this fact and the theoretical challenges facing the results from "one-period money" games, the discussion will be focused on the results for the gambles involving income. The OLS results for the income-subsistence methods show that socioeconomic factors are indeed significant for risk aversion. In order of coefficient magnitude the results show that sharecropping is significantly more common among the more risk averse farmers. "Crop tenure" is a dummy variable measuring the effect of co-owning a crop on the degree of aversion to risk. Crop ownership is dependent on wealth, credit availability, land ownership and labor requirements for the crop. Given the high cost of capital for the region, sharing the production of a crop is a way to decrease the capital requirements and risks associated with production.

Table 5.3

OLS REGRESSION OF SOCIOECONOMIC CHARACTERISTICS ON RISK AVERSION BY PROCUREMENT METHOD, FARMERS WITH CONSISTENT RISK COEFFICIENTS

Independent Variable	Coins Game	Risk Aversion With Subsistence at Risk	Risk Aversion With Subsistence Assured
Intercept	-2.401 (1.756)[a]	0.432 (0.914)	1.258[c] (0.480)
Age	0.036 (0.038)	-0.036 (0.021)	-0.033[d] (0.011)
Education	0.055 (0.107)	-0.166[d] (0.052)	-0.194[d] (0.027)
Crop Tenure Dummy (1 = shared crop ownership)	-0.144 (0.495)	-0.738[d] (0.236)	-0.784[d] (0.124)
Farming Experience	0.021 (0.025)	0.039[c] (0.014)	0.027[d] (0.007)
Level of Technology Dummy (1 = uses new inputs)	1.598[c] (0.595)	0.517[b] (0.283)	0.494[d] (0.149)
Wealth	$-0.68(10^{-6})$ $\{0.41(10^{-6})\}$	$0.48(10^{-6})$[c] $\{0.20(10^{-6})\}$	$0.34(10^{-6})$[d] $\{0.11(10^{-6})\}$
Income	$-4.62(10^{-6})$[b] $\{2.5\ (10^{-6})\}$	$-0.75(10^{-6})$ $\{1.29(10^{-6})\}$	$-1.78(10^{-6})$[c] $\{0.68(10^{-6})\}$
F	1.32	4.34	14.37
R^2	0.48	0.77	0.91
MSE	0.62	0.34	0.04
n	17	16	16

[a]Numbers in parentheses are standard errors.

[b]Significance $\geq$ 0.1 probability level.

[c]Significance $\geq$ 0.05 probability level.

[d]Significance $\geq$ 0.01 probability level.

An effect working in the opposite direction of risk aversion is the utilization of new inputs. The "Level of Technology" variable is a dummy which takes a value of 1 if the farmer uses at least two of the following inputs: fertilizer, hybrid corn seed, fungicide, and row planting of beans. This variable, however, is in turn affected by risk aversion since it attempts to measure a degree of technical innovation. Clearly, farmers who are averse to risk are expected to be less innovative than risk neutral or risk loving farmer. However, if the simultaneity between risk aversion and innovation is ignored the results suggest that the use of new inputs does not increase risk aversion. A similar problem occurs with income. "Income" is measured in gross margins generated by all the production enterprises on the farm, plus any off-farm or hired labor income that the farmer was able to obtain. It depends heavily on other factors such as credit, input availability, land quality, quality of the extension service and so forth, which are important in deciding which inputs to use. Coffee farmers, for instance, recognize that the use of fungicide--a relatively sophisticated input in traditional farming--is necessary to increase coffee production. Nevertheless, they also point out capital scarcity as the reason for not using fungicide with a corresponding decrease in income from coffee.

All this suggests that the relationship between risk aversion and the farming environment is more complex than the linear specification used for results in Table 5.3. As it is, the OLS model presents coefficients which have anticipated magnitudes and signs even in the case of the income and schooling variables. Contrary to expectations, the sign of the income coefficient is negative, indicating a direct

relationship to risk aversion.

A plausible explanation for the latter result is an apparent ratchet effect among farmers with respect to income. As income increases so does the risk premium used by the farmer in the decision making process, thus suggesting risk aversion. This type of behavior is perfectly possible considering that income increases are only attainable through increments in farm production. Since the level of technology currently in use varies only modestly the risk taking effect on income is being picked up by the wealth variable through the use of more land. "Age" indicates that as farmers get older they become more risk averse. And so does "Education". As discussed previously, younger--and presumably less risk averse--farmers tend to have more years of schooling than older farmers; hence the negative coefficient for schooling. The effect of education is represented by the years of experience in farming. This variable, as should be expected, is inversely related to risk aversion but on a relatively small scale. Finally, "Wealth," measured by market value of the farm, presents a significant effect moving opposite to risk aversion as expected.

Judgmental Input

Experience would suggest that farmers weight recent observations more highly than distant ones. This is not the case for estimates of parameters for the risk decision problem determined from time series data. For the experimentally obtained risk aversion coefficient estimates, the question is whether the option given is near the perceived uncertainty levels of the farmer. As the quadratic utility function employed to calculate the coefficient is itself an approximation, this

scaling problem can be crucial to the calculation of realistic estimates of risk attitudes and/or farm technology adoption plans.

To address these problems, subjective or judgmental estimates of the distributions for yields and prices were obtained from the sample farms. The procedure for eliciting these judgmental estimates has been developed and applied in a number of contexts (Jackson [1974], Falconer and Sivesind [1977]). Specifically, a set of referenced gambles is given to the farmer. By choices of these referenced gambles, the fractiles of the underlying distributions are obtained. The resulting subjective price and yield distributions are then used to build a judgmental covariance matrix for the risk program.

The Elicitation of Judgmental Input

The elicitation of subjective probabilities has been a subject of controversy ever since Savage outlined the problem in a rigorous manner (Savage [1971]). Due to their personal nature there are still doubts about the validity of the use of personal probabilities in non-laboratory conditions (Winkler [1971]) and the capacity of the individual to absorb all the pertinent information required by a probability distribution. These doubts have provoked two streams of thought, one which asserts that man has a processing system of limited capacity and is therefore unable to give consistent information (Hogarth [1975]), and another which asserts that the problem lies not on man's capacities but on the characteristics of the elicitation methods. The empirical results obtained so far, however, do not reject conclusively any of the above hypotheses. The only consensus is that in eliciting meaningful subjective probabilities three conditions are necessary (Hampton, Moore and Thomas [1973], Hendrickson and Buehler [1972])

a) The matter being elicited and the methodology used should be familiar to the person doing the assessment.

b) There is a need for judgmental probabilities, that is, there is a conviction that personal probabilities will add predictive accuracy to objective data.

c) The judgment being assessed should be expressed in probabilistic form.

Added to the above criteria there are caveats indicated by the accumulated empirical findings. First, the probability assessor must be knowledgeable about the factor being examined and possess the ability to extract information in probabilistic form (Winkler [1969]). Second, subjects tend to express their personal distribution in symmetric form such as a normal distribution. Third, inconsistencies are not at all uncommon (Winkler [1967]).

Accounting for these qualifications, interviews were conducted for the farmers sampled during the assessment of attitudes toward risk. The questioning procedure (described in Appendix B) is based on Raiffa's [1968] judgmental fractile method. This method attempts to find points in a cumulative distribution function (CDF) through the elicitation of equally likely probability intervals (Figure 5.1).

Let $f_{o.b}$ be a value of a random variable X such that $P(X \leq f_{o.b}) = o.b$, then its lowest possible value is $f_{o.o}$ and its highest possible value is $f_{1.0}$ with $f_{0.5}$ representing the mode of the distribution. Each $f_{o.b}$ is called a "point b fractile" of the subjective CDF. The elicitation procedure for each fractile in the distribution can be resumed as follows:

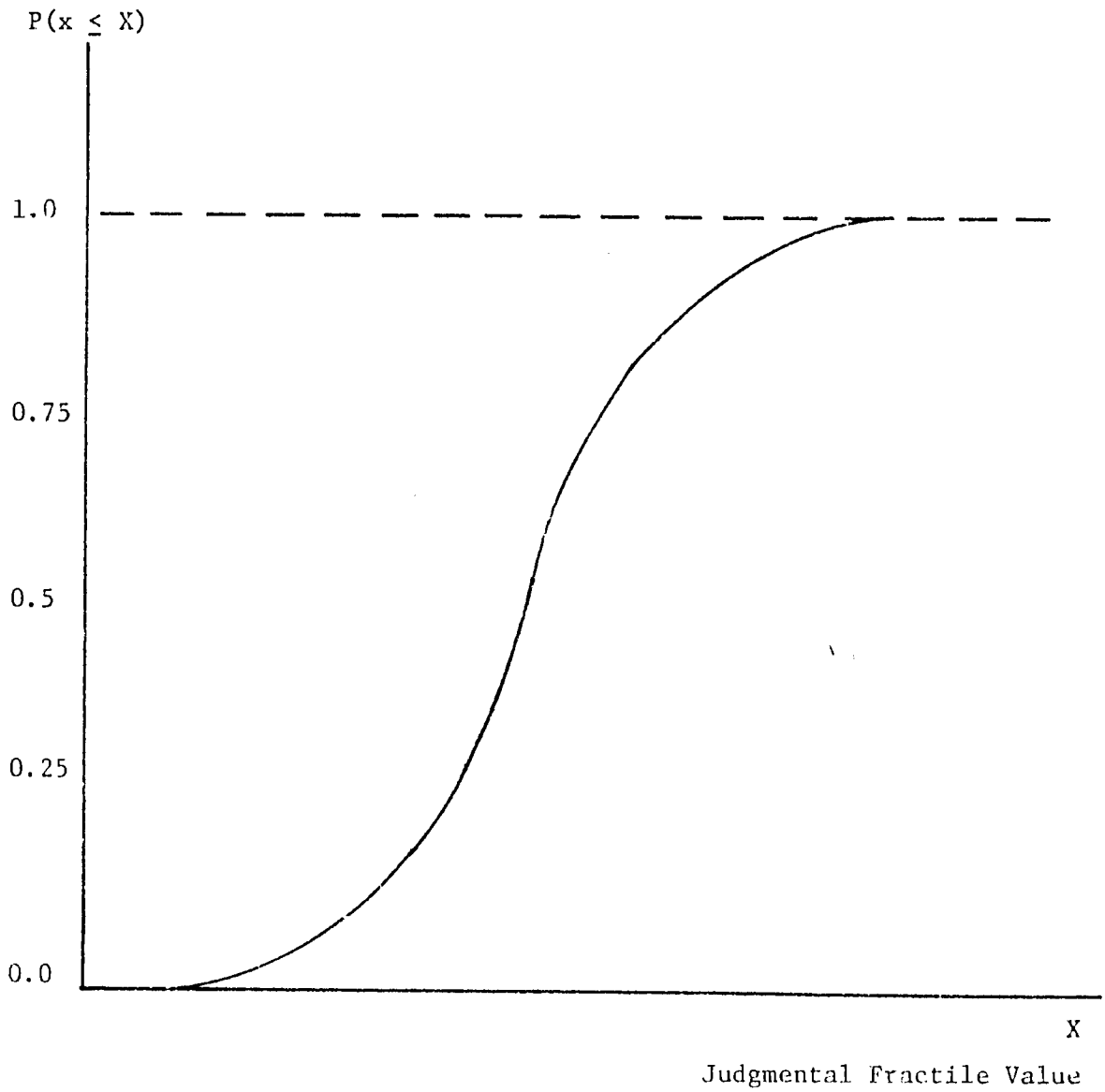

Figure 5.1. A judgmental cumulative density function.

a) Find the lowest ($f_{o.o}$) and the highest ($f_{1.0}$) possible values for X.

b) Find the value of $f_{0.5}$ such that it is equally likely for X to fall above or below it.

c) Find a value $f_{0.25}$ such that it is equally likely for X to fall below $f_{0.25}$ or between $f_{0.25}$ and $f_{0.5}$.

d) Find a value $f_{0.75}$ such that it is equally likely for X to fall above $f_{0.75}$ or between $f_{0.5}$ and $f_{0.75}$.

Although the method permits the elicitation of a large number of fractiles only five were deemed necessary for the farmers in Southern Huila. The results obtained from the questioning procedure were then processed to obtain the relevant parameters of the underlying distributions (Table 5.4).

Judgmental Price and Yield Distributions

The judgmental price and yield distributions obtained from the field interviews may be referenced by the 1979 actual prices and yields actually obtained by farmers (Table 5.5). The actual figures were useful for calibrating the judgmental figures as the interview proceeded. The judgmental fractiles for product prices and their corresponding means and variances are shown in Tables 5.6 and 5.7. The subjective assessments of prices, as indicated by the coefficients of variation, suggest that high price variation occurs for the perishable crops: onions, tomatoes, cassava and platano. The high price variation reported for cassava and platano is not reflected in aggregated government figures. This discrepancy tends to corroborate the need for judgmental assessment in risk modeling.

Table 5.4

FORM FOR RECORDING AND PROCESSING JUDGMENTAL FRACTILES AND SUBJECTIVE DISTRIBUTIONS

Fractile	Judgmental Fractile Value	Histogram	
		Value (X_i)	Probability (P_i)
0.0	Y_0	X_0	0.125
0.25	Y_1	X_1	0.25
0.50	Y_2	X_2	0.25
0.75	Y_3	X_3	0.25
1.0	Y_4	X_4	0.125

$$X_0 = (Y_0 + \frac{Y_1 + Y_0}{2})/2$$

$$X_i = (\frac{Y_i + Y_{i-1}}{2} + \frac{Y_i + Y_{i+1}}{2})/2; \; i = 1, 2, 3.$$

$$X_4 = (Y_4 + \frac{Y_4 + Y_3}{2})/2$$

$$\text{Mean} = \sum_{i=0}^{4} X_i P_i$$

$$\text{Variance} = \sum_{i=0}^{4} (X_i - \overline{X}) P_i$$

Table 5.5

PRICES AND YIELDS OBTAINED BY INTERVIEW FARMERS IN 1979

Crop	Price Pesos Per Kilogram	Yields Kilograms Per Hectare
Coffee	55.26	606.7
Platano	43.32	219.71[a]
Corn	9.23	1509.66
Beans	38.17	895.64
Brown Sugar	12.3	2687.50
Cassava	3.5	6560.42
Tomatoes	6.05	23521.43
Onions	8.64	11437.50

[a]In bunches per hectare. One bunch weighs about 12 kilograms.

Table 5.6

JUDGMENTAL FRACTILES FOR PRODUCT PRICES FROM INTERVIEW FARMERS IN SOUTHERN HUILA

Crop	Price Fractile (Pesos Per Kilogram)				
	0.0	0.25	0.5	0.75	1.0
Coffee	45.79	50.03	53.66	56.00	58.53
Platano[a]	29.44	43.33	50.56	61.33	86.16
Corn	6.46	7.64	8.93	9.75	10.99
Beans	26.22	32.91	34.58	39.38	43.24
Brown Sugar	10.85	12.83	14.78	15.6	19.85
Cassava	2.16	3.54	4.23	4.9	5.68
Tomatoes	2.94	5.23	7.27	9.71	13.02
Onions	5.86	7.00	9.15	10.20	13.60

[a]Pesos per bunch.

Table 5.7

DISTRIBUTION OF JUDGMENTAL PRICES FROM INTERVIEW FARMERS IN SOUTHERN HUILA, PESOS PER KILOGRAM

Crop	Mean	Variance	Standard Deviation	Coefficient of Variation
Coffee	52.90	12.50	3.53	6.68
Platano[a]	53.59	208.68	14.44	26.95
Corn	8.76	1.56	1.24	14.26
Beans	35.31	19.95	4.46	12.65
Brown Sugar	14.71	5.15	2.27	15.43
Cassava	4.12	0.86	0.93	22.54
Tomatoes	7.57	7.57	2.75	36.30
Onions	9.09	4.33	2.08	22.90

[a]Pesos per bunch.

The judgmental results for yields, however, present variations more closely associated with biophysical variables (Tables 5.8 and 5.9). Low yield variation is observed for sugarcane, cassava, and coffee, three crops known for good drought resistance. The yield variance of platano is also low. The yield variation for platano is reflected in the quality of the bunch and therefore in terms of price variation. Corn, on the other hand, had a high yield variation. This seems to contradict the fact that corn is a farm staple; however, the reported variation is a product of extremely varied plant densities in the corn-beans association. Finally, the relatively high yield variation for onions, tomatoes, and beans is likely due to drought problems, disease and insect attacks.

The Judgmental Distribution of Gross Margins

The distribution of gross margins is derived from the judgmental distributions for prices and yields (Table 5.10). The subjective gross margin figures are very similar to time series averages but with larger variances, reflecting the farm level situation unaccounted for in regional figures. Tomatoes and onions, the most profitable crops, also have the largest variance while the less profitable crops (corn, platano, and cassava) are the home-consumed staples.

Since the prices and yields elicited from the farmers may not be independent the variance of gross margins was computed as

$$S^2 = \overline{P}s_y^2 + \overline{Y}s_p^2 + 2\overline{PY} \text{ cov } (P, Y)$$

where

P = product price,

Table 5.8

JUDGMENTAL FRACTILES FOR CROP YIELDS FROM INTERVIEW FARMERS IN SOUTHERN HUILA

Crop	Yield Fractiles (Kilograms Per Hectare)				
	0.0	0.25	0.5	0.75	1.0
Coffee	338.14	413.02	544.08	588.48	654.84
Platano[a]	99.37	161.24	228.18	238.63	245.39
Corn	444.44	1084.94	1589.61	1895.96	2260.33
Beans	227.96	722.38	973.89	1142.87	1322.34
Brown Sugar	2342.19	3093.75	3668.75	3817.19	4012.50
Cassava	2930.36	4615.38	5452.18	5831.6	6395.64
Tomatoes	6286.88	13830.63	22506.25	26412.5	32499.38
Onions	4062.5	7206.25	13625.0	15197.5	17437.5

[a]In bunches per hectare. One bunch weighs about 12 kilograms.

Table 5.9

DISTRIBUTION OF JUDGMENTAL YIELDS FROM INTERVIEW FARMERS IN SOUTHERN HUILA, KILOGRAMS PER HECTARE

Crop	Mean	Variance	Standard Deviation	Coefficient of Variation
Coffee	510.25	8508.25	92.24	18.07
Platano[a]	198.38	1898.97	43.57	21.96
Corn	1472.09	248356.7	498.35	33.85
Beans	893.73	85347.11	292.14	32.68
Brown Sugar	3421.87	217085.98	465.92	13.61
Cassava	5105.50	835428.32	914.01	17.90
Tomatoes	20490.10	53504981.2	7314.70	35.69
Onions	11666.44	16078241.60	4009.76	34.37

[a]Bunches per hectare.

Table 5.10

JUDGMENTAL DISTRIBUTION OF GROSS MARGINS FROM INTERVIEW FARMERS IN SOUTHERN HUILA, PESOS PER HECTARE

Crop	Mean	Variance	Standard Deviation	Coefficient of Variation
Coffee	20484.2	27170363	5212.5	19.3
Platano	10631.2	8710546	2951.3	28.0
Corn	11552.5	22825861	4777.6	37.0
Beans	30215.1	124048106	11137.7	35.0
Brown Sugar	45421.7	108394303	10411.3	21.0
Cassava	20752.7	37316229	6108.0	29.0
Tomatoes	92717.0	6649319849	81543.3	53.0
Onions	88491.0	1987471498	44581.0	42.0

Y = yield per hectare,

s_y^2 = variance of yields,

s_p^2 = variance of product prices.

Judgmental Covariance Estimation

The correlation coefficients needed in the elaboration of the judgmental variance-covariance matrix were calculated from two-way tables of prices and yields obtained from the interviews. In general, farmers were unable to assert any kind of relationship among sale prices for a given pair of products. In all instances they argued that product prices were completely independent. Yields, on the other hand, were somewhat different. Farmers readily recognized zero or negative correlations among crops which depended on different climatic constraints. Cassava, for instance, grows well during dry spells and rots if rain becomes excessive. Coffee, however, suffers more from dry weather at flowering than from excess of precipitation. The resulting correlations (Table 5.11) were used in the computation of the covariance matrix shown in Table 5.12. The questioning procedure used for the assessment of the two way tables is very similar to the one used for the price and yields distribution. Differences relate to the use of crop A as a reference value in the elicitation of a fractile value for crop B.

Conclusions

The objectives of this chapter were twofold. The first was the estimation of the risk aversion coefficient with which to weight the profit variance associated with the farm portfolio. The second objective was to obtain a more adequate measure of profit variance. With

Table 5.11

JUDGMENTAL CORRELATION COEFFICIENTS FOR YIELDS FOR THE MODEL CROPS AND TECHNOLOGIES IN SOUTHERN HUILA[a]

	Corn	Beans	Cassava	Brown Sugar	Coffee	Platano	Tomatoes	Onions
Corn	1.0 (0.0)	0.15 (0.28)	0.47 (0.01)	-0.11 (0.72)	0.14 (0.49)	-0.20 (0.40)	-- --	0.14 (0.90)
Beans		1.0 (0.0)	0.35 (0.04)	0.811 (0.004)	0.55 (0.002)	-0.007 (0.97)	0.18 (0.59)	0.35 (0.55)
Cassava			1.0 (0.0)	0.01 (0.96)	0.04 (0.82)	-0.27 (0.24)	0.02 (0.95)	-- --
Brown Sugar				1.0 (0.0)	0.67 (0.14)	-0.12 (0.85)	-- --	-- --
Coffee					1.0 (0.0)	-0.20 (0.35)	-0.99 (0.09)	-0.72 (0.16)
Platano						1.0 (0.0)	-0.97 (0.15)	0.81 (0.18)
Tomatoes							1.0 (0.0)	-0.15 (0.90)
Onions								1.0 (0.0)

[a]Numbers in parentheses are the probability levels for H_o: $\rho = 0$.

Table 5.12

JUDGMENTAL VARIANCE-COVARIANCE MATRIX FOR GROSS MARGINS FOR THE MODEL CROPS AND TECHNOLOGIES IN SOUTHERN HUILA

	Corn-Beans	Cassava	Brown Sugar	Coffee-Platano	Tomatoes	Onions
Corn-Beans	163552006	276565310	448833855	263261433	7326147713	2567877523
Cassava		37307664	944953	65349789	10299976	0.0
Brown Sugar			108388921	209321424	0.0	0.0
Coffee-Platano				35247315	5376946708	1900447854
Tomatoes					6649260849	-546562616
Onions						1987465561

respect to the first objective the results indicate that the coefficient of risk aversion for Southern Huila farmers varies within the range of $\phi = -0.05$ to $\phi = -.5$, as corroborated by the regressions on socioeconomic variables. In addition, the experience gathered from the elicitation procedure helped to point out a problem for the future; the quantification (or monetarization) of home consumed items in terms of market prices.

The latter items include house rent, transportation, and some food products. In assigning a monetary value to these goods the interviewer may use a value which, while correct, may sound excessive to a farmer who is not used to pegging the value of the foods to a current market price. Hence, when faced with questions involving allocation of their total expenses in terms of a given monetary income, some farmers felt at a less and thus behaved inconsistently. The fact that inconsistencies do arise even when interview bias is minimized, as in the case of Huila, raises serious questions as to the viability of risk procurement methods such as income gambles. Nevertheless, the results from the interviews indicated that farmers are generally risk averse when faced with uncertain total incomes and approximately neutral when their sustenance is assured.

In terms of the second objective, the procurement of a better measure of profit dispersion, the results are quite encouraging. The judgmental prices and yields obtained follow closely the conventional wisdom for Southern Huila agriculture. This in turn suggests that by assessing profit variance at the farm level a more accurate description of production risk can be obtained. The above assertion becomes especially important in cases where there are not enough data at an appropriate

level of disaggregation to build an adequate risk model.

FOOTNOTES

CHAPTER V

[1]For more details on the regional characteristics see Instituto Colombiano Agropecuario (ICA), Distrito de Transferencia de Tecnologia Sur del Huila, Diagnostico Distrital, Regional 6, Ibague, Colombia, 1978.

CHAPTER VI

THE IMPACT OF NEW BEAN TECHNOLOGY

Introduction

The objective of this chapter is to detail and discuss the results of introducing the new bean technology into the risk programming model. In addition, a discussion of measurement for the quadratic portion of the objective function is included. The variance-covariance matrix is calculated from regional time series data which, as previously indicated, underestimate the amount of price and yield variation actually faced by farmers. For this reason, an alternative measure of price and yield dispersion based upon the subjective distributions is incorporated as well. Comparisons are made between the model results when time series estimates are used for the calculation of the variances and the results when subjective variance estimate is used as an alternative. This comparison is for the different risk levels estimated for Southern Huila. The discussion concludes with an analysis of the impact of new bean technology on the small farm system and its relationship to the level of risk aversion.

Model Results With Two Covariance Measures

The optimal solutions to the quadratic programming problem formulated for the current technology are shown in Tables 6.1 and 6.2. Table 6.1 shows the model results based on time series variance esti-

mates. Table 6.2 reports results for the subjective variance estimates. Both tables include the solutions to the programming problem for different risk aversion levels, including a riskless or linear case. The farm size used for the comparisons is 15.8 hectares, a size found at the upper level of the small farm category in Southern Huila. Repeated efforts were made to obtain a feasible quadratic solution for the 2.4 hectare farm size for the time-series case. Unfortunately, the attempts were fruitless due to rounding problems introduced by the size of the model. Consequently, only the case of subjective variance is discussed for this farm size.

Model results for the time series case and the 15.8 hectare farm size indicate that at higher levels of risk aversion ($\phi = -0.5$) the farm plan is dominated by corn and beans in association. A large portion of the farm land is as well left idle or for pasture production (Table 6.1, column 1). Beans in monoculture are also present and also onions and tomatoes. The latter activities absorb a great deal of the available family labor during the second semester. Labor sales are small and the gross margin is well below the mean of 182,380 pesos observed in the region (Table 4.2). As risk aversion levels decrease the gross margin increases and the farm enterprise composition shifts toward coffee production. However, the farm remains fairly diversified at low levels of risk aversion ($\phi = -0.05$).

Farm enterprise composition changes drastically in the risk neutral case. In the riskless or linear case the gross margin increases by 50 percent over the gross margin at low ($\phi = -0.05$) risk levels. Coffee acreage increases almost fourfold, sugarcane production becomes important, and the corn-bean association diminishes slightly. For this

Table 6.1

LINEAR AND QUADRATIC SOLUTIONS UNDER TIME-SERIES VARIANCE, CURRENT LEVELS OF BEAN TECHNOLOGY, AND ESTIMATED DEGREES OF RISK AVERSION FOR SMALL FARMS IN SOUTHERN HUILA, FARM 3

	Farm Size, 15.8 Hectares			
	Quadratic Solutions			Linear Solution
Item	$\phi = -0.5$	$\phi = -0.25$[a]	$\phi = -0.05$	$\phi = 0$
Gross Margin (Pesos)	131,054	167,646	172,191	248,780
Crop Area (Hectares)				
New Caturra Coffee		1.55	1.76	
Low Technology Caturra Coffee				5.1
Old Coffee				
Onions	0.53	0.2	0.13	
Sugarcane				4.75
Tomatoes	0.44	0.07		
Corn-Beans	3.12	2.18	2.10	1.83
Beans	0.93	0.44	0.5	
Household, Pastures, and Other Activities	12.1	11.84	11.79	4.11
Labor Sales (Man Days)	8.4	--	--	--
Capital Borrowing (Pesos)	50,000	50,000	50,000	75,000

[a]Estimated from interpolation.

1.0 U.S. Dollar = 40.0 Pesos.

case, farm income is almost double that with high risk aversion (ϕ = -0.5). This income increase is due to an expansion of the cultivated area and an increment of 50 percent in capital borrowing.

The quadratic solutions shown in Table 6.1 do not, however, resemble actual farm plans found in the area (Arcia and Sanders [1980]). The presence of onions and tomatoes in the optimal plans and the relatively low level of coffee area indicate that the time series variance estimate may be misrepresenting the decision problem. Either the model is misrepresenting the technology constraints, the normative decision criterion or the distribution of net returns. As indicated at Chapter III, the implicit hypothesis is that the source of the difficulty is the time series estimates of the underlying distributions.

The model incorporating subjective variance estimates yields levels of farm income similar to those reported in Table 6.1 but substantially different farm plans. Observe from Table 6.2 that at the high (ϕ = -0.5) risk aversion level, the main crop is coffee, with labor sales as the only other source of income. This farm plan is consistent with observed behavior among the poorest farmers. At this risk aversion level, farmers tend to stick with stable permanent crops and sell their labor to provide for daily cash needs. Capital utilization remains low, at less than 12,000 pesos. As risk aversion decreases, however, the area allotted to coffee production increases rapidly. At low levels of risk aversion (ϕ = -0.05), half the farm is planted with coffee. No other crops or enterprises appear in the solution until the level of risk aversion approaches zero, when the areas of sugarcane and corn-beans start to increase, reaching a maximum of 4.75 hectares for sugarcane and 1.83 hectares for corn-beans. No family labor is sold

Table 6.2

LINEAR AND QUADRATIC PROGRAMMING SOLUTIONS UNDER SUBJECTIVE VARIANCE, CURRENT LEVELS OF BEAN TECHNOLOGY, AND ESTIMATED DEGRESS OF RISK AVERSION FOR SMALL FARMS IN SOUTHERN HUILA, FARM 3

	Farm Size, 15.8 Hectares			
	Quadratic Solutions			Linear Solution
Item	$\phi = -0.5$	$\phi = -0.25$	$\phi = -0.05$	$\phi = 0$
Gross Margin (Pesos)	113,227	169,051	204,935	248,780
Crop Area (Hectares)				
New Caturra Coffee	1.38	1.87		
Low Technology Caturra Coffee		0.67	5.96	5.1
Old Coffee	0.81	2.21	2.21	
Sugarcane				4.75
Corn-Beans				1.83
Household, Pastures, and Other Activities	13.61	11.05	7.63	4.11
Labor Sales (Man Days)	180	162	162	
Capital Borrowing (Pesos)	11,477	57,260	65,586	75,000

1.0 U.S. Dollar = 40.0 Pesos.

in the risk neutral case.

Based on the observed farmer behavior in Southern Huila, the plans which resemble actual plans the most are associated with the solutions for $\phi = -0.5$ and $\phi = 0$. Thus, the model results suggest that the use of subjective variance in the objective function generates better estimates than the more traditional approach, incorporating variances based on time series data. Furthermore, comparing model results with actual field data (Table 5.1) and farm plans observed in the area (Tables 3.2, 4.1, 4.2), it can be concluded that Southern Huila farmers tend to behave in either a strongly risk averse fashion (i.e., $\phi = -0.5$) or with risk neutrality (i.e., $\phi = 0$). The continuous presence of coffee and the inverse relationship existing between cash crops and the levels of risk aversion also may indicate that farmer behavior is adaptive. Risk averse farmers with little experience tend to organize their production around more secure activities such as coffee, which present stable yields and a guaranteed price, while working as laborers to subsist during the period prior to coffee production. As farmers progress, both in terms of capital and experience, they start to increase the area allocated to annual cash crops such as corn and beans. The reason why they do not continue expanding coffee production seems to be the constraints on harvest labor and the additional capital needed for expansion. Therefore, once the limit on coffee area is reached farmers go into cash crops rather than continue as laborers (an activity which presents a fixed and secure wage rate). This suggests that farmers who currently are risk neutral may have been risk averse. If this conclusion is correct, it has important policy implications.

The model results for the smaller farm size (2.4 hectares) under current technology levels are available only for the case of subjective variance estimates. As already mentioned earlier, the results for the time series variance case were not obtainable due to difficulties with the computing algorithm, likely due to the similarity of the enterprise variance estimates when using time series data.

The results for the subjective variance case for the 2.4 hectare farm are shown in Table 6.3. As the risk aversion level shifts from high to low the coffee activity changes toward a more intensive use of capital and cash crops begin to increase in area. Also, labor sales decline and capital use increases almost three-fold. The changes occurring in the 2.4 hectare farm as risk aversion decreases are similar in nature to the changes in the composition of the 15.8 hectare farm. The trend, as ϕ approaches zero, is to expand coffee production and start the production of annual crops such as corn and beans. The above solutions, however, should be viewed with caution. The farm plans presented in Tables 6.2 and 6.3 are all similar to actual plans found in the region (Tables 3.2, 4.1, 4.2). However, the farm plans do not include cassava cultivation, a Southern Huila staple. This may be due to the low market prices reported by farmers. As mentioned earlier, staple crops such as cassava present serious problems with respect to price estimation since the clearing price for the marketable surplus may not reflect the true value of the crop as a staple. Another problem is the absence of sugarcane on the larger farm. This crop is not special in terms of risk or income. Nevertheless, the solutions for the 15.8 hectare farm consistently show sugarcane in the basis but not in the solution. Future model refinements should include a

Table 6.3

LINEAR AND QUADRATIC PROGRAMMING SOLUTIONS UNDER SUBJECTIVE VARIANCE, CURRENT LEVELS OF BEAN TECHNOLOGY, AND ESTIMATED DEGREES OF RISK AVERSION FOR SMALL FARMS IN SOUTHERN HUILA, FARM 1

	Farm Size, 2.4 Hectares			
	Quadratic Solutions			Linear Solution
Item	$\phi = -0.5$	$\phi = -0.25$	$\phi = -0.05$	$\phi = 0$
Gross Margin (Pesos)	101,535	116,142	120,969	126,991
Crop Area (Hectares)				
New Caturra Coffee	1.19	1.34	1.77	1.95
Low Technology Caturra Coffee	0.24	0.71		
Old Coffee	0.34	0.34	0.34	
Corn-Beans			0.28	0.44
Household, Pastures, and Other Activities	0.63	0.01	0.01	
Labor Sales (Man Days)	183	180	170	165
Capital Borrowing (Pesos)	8,872	16,598	23,631	23,878

1.0 U.S. Dollar = 40.0 Pesos.

revision in the activity coefficients.

The Impact of New Bean Technology

After choosing the subjective variance model as more adequate for representing the small farm system, the introduction of new bean technology was simulated and its impact measured. Tables 6.4 and 6.5 show the impact of including the Better Agronomy technology as a new activity in the risk programming model for the two typical farm sizes in Southern Huila. This new activity has higher profits than current bean technologies, a somewhat lower level of labor use, and slightly higher capital utilization (Table A-2.1). In a risk neutral context this activity would be expected to dominate most of the annual crops.

Table 6.4 presents the different farm plans for the alternative levels of risk aversion and the 15.8 hectare farm. Except for the linear case ($\phi = 0$), the other farm plans remain unchanged. That is, the introduction of new bean technology produced no effect on the enterprise composition for the risk averse farms.

In the risk neutral case, however, the Better Agronomy technology does have an impact on farm income and employment. The area allotted to bean cultivation increases from zero to three hectares. Sugarcane and cassava also appear in the linear solution and the coffee area increases slightly. Due to this significant change in the farm plan, family labor is fully employed on the farm and no labor sales occur. Moreover, the expansion in the cultivated area increases the need for working capital by almost 30 percent, from 65,586 pesos to 90,000 pesos per year. As a consequence, farm income increases from 204,935 pesos in the case of lowest risk aversion ($\phi = -0.05$) to 270,015 pesos, an increase of 31 percent. Most of the increased income comes

Table 6.4

LINEAR AND QUADRATIC SOLUTIONS UNDER SUBJECTIVE VARIANCE, NEW LEVELS OF BEAN TECHNOLOGY, AND ESTIMATED DEGREES OF RISK AVERSION FOR SMALL FARMS IN SOUTHERN HUILA, FARM 3

	Farm Size, 15.8 Hectares			
	Quadratic Solutions			Linear Solution
Item	$\phi = -0.5$	$\phi = -0.25$	$\phi = -0.05$	$\phi = 0$
Gross Margin (Pesos)	113,227	169,051	204,935	270,015
Crop Area (Hectares)				
New Caturra Coffee	1.38	1.87		
Low Technology Caturra Coffee		0.67	5.96	6.4
Old Coffee	0.81	2.21	2.21	1.0
Sugarcane				1.2
Beans, Better Agronomy				3.0
Cassava				4.15
Household, Pastures, and Other Activities	13.61	11.05	7.63	0.05
Labor Sales (Man Days)	180	168	162	
Capital Borrowing (Pesos)	11,477	57,260	65,586	90,000

1.0 U.S. Dollar = 40.0 Pesos.

Table 6.5

LINEAR AND QUADRATIC SOLUTIONS UNDER SUBJECTIVE VARIANCE, NEW LEVELS OF BEAN TECHNOLOGY, AND ESTIMATED DEGREES OF RISK AVERSION FOR SMALL FARMS IN SOUTHERN HUILA, FARM 1

	Farm Size, 2.4 Hectares			
	Quadratic Solutions			Linear Solution
Item	$\phi = -0.5$	$\phi = -0.25$	$\phi = -0.05$	$\phi = 0$
Gross Margin (Pesos)	101,535	116,142	120,969	133,194
Crop Area (Hectares)				
New Caturra Coffee	1.19	1.34	1.77	2.05
Low Technology Caturra Coffee	0.25	0.72		
Old Coffee	0.34	0.33	0.34	
Beans, Better Agronomy				0.68
Corn-Beans				
Household, Pastures, and Other Activities	0.62	0.01	0.01	0.01
Labor Sales (Man Days)	183	180	170	20
Capital Borrowing (Pesos)	8,871	16,598	23,631	28,898

1.0 U.S. Dollar = 40.0 Pesos.

from the adoption of the Better Agronomy technology (27 percent).

In the 2.4 hectare farm, the adoption pattern is identical (Table 6.5). The new technology appears in the programming solution only for risk neutrality, accounting for a 10 percent income increase over the low level (ϕ = -0.05) of risk aversion. Farm enterprise composition is altered significantly with the bean plantings accounting for one-fourth of the total area per year (there are two bean plantings per year). The sale of family labor decreases from 170 to 20 man days per year. Capital needs, however, increase only 22 percent, a figure significantly lower than for the larger farm size.

Parametric Solutions on New Bean Technology

Given that modifications in the objective function through the inclusion of new bean technologies has produced only modest overall effects, the assumption of a deterministic constraint set should be re-examined. Among the suggested changes in farm policy, agrarian reform schemes and expanded credit have been promoted as primary vehicles for technology adoption. As discussed in Chapter II, such assertions may have been oversold. Table 6.6 shows the impact of increasing the small farm size by 50 percent and 100 percent, with no restrictions as to capital use. As the results in Table 6.6 indicate, the new bean technology has not been adopted. Income and capital use have increased substantially but the area allocated to beans remains at zero. Hence, the assumption that by providing more land and more credit would induce technology adoption seems to be unwarranted. What the above results in turn suggest is that a new approach to technological change should be undertaken. Namely, these changes should stress the priority of

Table 6.6

IMPACT OF CHANGES IN THE CONSTRAINTS SET ON
BEAN TECHNOLOGY ADOPTION, FARM 1

	Increase in Farm Size					
	50 Percent			100 Percent		
	$\phi = -0.5$	$\phi = -0.25$	$\phi = -0.05$	$\phi = -0.5$	$\phi = -0.25$	$\phi = -0.05$
Farm Income (Pesos)	100,701	143,732	143,732	107,748	165,943	165,943
Area in Beans (Percent of Total Area)	0	0	0	0	0	0
Capital Borrowing (Pesos)	8,226	43,750	43,750	10,055	61,796	61,796

modifications in the institutional structure aimed at reducing the variance (both real and subjective) associated with the new technology to be promoted.

Conclusions

The results presented in this chapter served to clarify important points in three areas of risk modeling; the use of subjective information, the importance of risk aversion, and the impact of new technology on the farming system. With respect to the first area, the results seem to back the intuitive assertion that the use of subjective variances when the time series data are of a doubtful validity can provide for improved programming results. Obviously, this procedure can greatly facilitate farm risk modeling in regions where only scanty or poor quality time series data are available. An added benefit not brought forward by the model is the great deal of additional information about the farm obtained during the process of procuring the subjective information. The fact that farmers try to identify, albeit slowly, their farming activities in a probabilistic farmework helps the interviewer get a clearer picture of the complementary nature of the alternative crops in the farm plan as well as to understand the process of farm decision making.

The second area where the results are useful is for examining risk aversion. Much has been written about risk aversion and its influence on farm behavior. The results from this study indicate that farmers are strongly influenced by risk aversion in their decisions, that risk aversion does have an influence on the degree of adoption of new technology, and that risk aversion is adaptive. Therefore, if new

farm technologies are to be promoted it is clear that the less risk averse farmers should be targeted first. This will not only lead to a more rapid acceptance of the new technique but also decrease the cost of promotion since the more risk averse farmers will follow suit after they become acquainted with the results obtained by the innovators.

The third area where the results shed light relates to the impact of new bean technology. The results clearly show that new technology per se has limited impact on farm income and employment. For risk averse farmers, the level of adoption of the new technology generated by the CIAT on-farm technology trials is nil. For risk neutral farmers, the impact is certainly significant with income increasing from 10 to 27 percent depending on farm size. Given such limited impact, the suggested questions for evaluating the returns to bean technology research are: first, what does the above bean technology need to have in order to be more attractive to the risk averse?, and second, to what degree new technology, in its present form, may be complemented by institutional change? These questions are the subject of the next chapter.

CHAPTER VII

THE IMPACT OF ON-FARM STORAGE AND YIELD STABILITY

Introduction

On measuring the impact of new alternatives for bean production in small farm systems, two further questions become relevant. First, if technology alone does not dramatically affect small farm cropping patterns and incomes, are there possible complementarities between a new technology and the institutional framework in which the farm operates? If yes, how can changes in the institutional factors help induce adoption? The second question relates more to the biophysical nature of the new technology. One of the problems for the new technology adoption is farmer uncertainty for yield distributions. New technologies with improved yield stability or other desirable characteristics vis-a-vis the situation in which the farmer finds himself should be designed with the institutional framework as perhaps variable.

The present chapter addresses the above two questions. The impact of institutional change, as related to new technology, is measured through the simulation of on-farm storage. The impact of bean yield stability, on the other hand, is studied by reducing the variance of yields below that from currently available bean technologies.

The Impact of On-Farm Storage

The impact of on-farm storage is measured by including the storage budget (Table A-2.2) as a new activity in the risk programming

model. Storage can be applied to all of the bean or corn-bean technologies. Harvested beans are stored for a maximum of six months and sold at a higher price. Beans stored at mid-year are sold at the end of the year. Beans stored at the beginning of the year are sold at mid-year. Besides the additional cost of storage (materials and labor) and the associated capital, no other costs are assumed. The results are shown in Tables 7.1 for the 15.8 hectare farm and in Table 7.2 for the 2.4 hectare farm.

Results for the larger farm size (Table 7.1) indicate that for risk averse farmers the use of on-farm storage is not an attractive alternative. For risk neutral farmers, however, the technology is attractive enough to dominate the other activities in the model. In fact, the results indicate that in the case of risk neutrality the diversified farm becomes a bean farm. Under these circumstances expected farm income more than doubles.

For the smaller farm (2.4 hectares), however, the results for new technology under storage are more far-reaching (Table 7.2). Although at higher levels of risk aversion ($\phi = -0.5$ and $\phi = -0.25$) storage availability brings no change into the farm plan, the storage activity enters the solution at the low level of risk aversion ($\phi = -0.05$) and becomes dominant when risk is neutral. The proportionate increase in income, however, is not as great as for the larger farm.

Changes in the farm plans induced by the availability of storage are significant. The benefits derived from the price increase effect of storage are large enough to divert resources away from coffee production, currently the main source of farm income. As a consequence, coffee in less capital intensive farms disappears from the farm plan in

Table 7.1

LINEAR AND QUADRATIC SOLUTIONS UNDER SUBJECTIVE VARIANCE, NEW BEAN TECHNOLOGY, ON-FARM STORAGE, AND ESTIMATED DEGREES OF RISK AVERSION FOR SMALL FARMS IN SOUTHERN HUILA, FARM 3

	Farm Size, 15.8 Hectares			
	Quadratic Solutions			Linear Solution
Item	$\phi = -0.5$	$\phi = -0.25$	$\phi = -0.05$	$\phi = 0$
Gross Margin (Pesos)	113,227	169,051	187,696	405,458
Crop Area (Hectares)				
New Caturra Coffee	1.38	1.87	0.9	
Low Technology Caturra Coffee		0.67	3.42	
Old Coffee	0.81	2.21	2.21	
Beans, Better Agronomy and Storage				
First Semester				4.92
Second Semester				6.62
Household, Pastures, and Other Activities	13.61	11.05	9.27	8.18
Labor Sales (Man Days)	180	168	165	--
Capital Borrowing (Pesos)	11,477	57,260	61,586	90,000

1.0 U.S. Dollar = 40.0 Pesos.

Table 7.2

LINEAR AND QUADRATIC SOLUTIONS UNDER SUBJECTIVE VARIANCE, NEW BEAN TECHNOLOGY, ON-FARM STORAGE, AND ESTIMATED DEGREES OF RISK AVERSION FOR SMALL FARMS IN SOUTHERN HUILA, FARM 1

	Farm Size, 2.4 Hectares			
	Quadratic Solutions			Linear Solution
Item	$\phi = -0.5$	$\phi = -0.25$	$\phi = -0.05$	$\phi = 0$
Gross Margin (Pesos)	101,535	116,142	132,949	178,664
Crop Area (Hectares)				
New Caturra Coffee	1.19	1.34	1.90	0.62
Low Technology Caturra Coffee	0.24	0.71		
Old Coffee	0.34	0.34		
Beans, Local Technology				0.28
Corn-Beans, Local Technology			0.49	
Beans, Better Agronomy and Storage				
First Semester				1.78
Second Semester			0.34	1.50
Corn-Beans, Storage				0.17
Household, Pastures, and Other Activities	0.63	0.01	0.01	0.01
Labor Sales (Man Days)	183	180	150	--
Capital Borrowing (Pesos)	8,871	16,598	27,936	30,000

1.0 U.S. Dollar = 40.0 Pesos.

favor of the more flexible bean technologies. Furthermore, the release of family labor from coffee activities induces a reallocation to production of corn-beans, a labor utilization pattern more compatible with new bean technology.

Sensitivity to Changes in the Constraint Set

The impact of relaxing the constraint set and allowing for increments in capital availability as well as substantial increments in the farm size is identical to that for Better Agronomy in the preceding chapter (Table 7.3). Hence, on simulating the effects of land reform programs the conclusion is clear. Technology promotion should rely on means for reducing the level of physical and judgmental uncertainty associated with the new farm practices.

In light of the above results a logical step is to examine the impact of a reduced profit variance for the new technology, in combination with storage, Better Agronomy, and higher bean prices. This is the topic of the next section.

Marketing Boards, Yield Stability, and Technology Adoption

Up to this point the programming results have indicated that efforts to increase farm income through modifications in the linear component of the objective function have been largely unsuccessful. Furthermore, relaxing the assumption of a predetermined constraint set by expanding land and capital use has yielded similar results. A major point of this study has been the incorporation of the farmers' perception of risk by means of a subjective quadratic element in the objective function. It appears that within this framework, the key to

Table 7.3

IMPACT OF CHANGES IN THE CONSTRAINT SET
ON THE ADOPTION OF STORAGE, FARM 1

	Increase in Area					
	50 Percent			100 Percent		
	$\xi = -0.5$	$\xi = -0.25$	$\xi = -0.05$	$\xi = -0.5$	$\xi = -0.25$	$\xi = -0.05$
Farm Income (Pesos)	100,701	143,732	143,732	107,748	165,943	165,943
Area in Beans (Percent of Total Area)	0	0	0	0	0	0
Capital Borrowing (Pesos)	8,226	43,750	43,750	10,055	61,796	61,796

technology adoption rests with the quadratic portion of the objective function. That is, if the profit variance associated with new technology is reduced the associated activities will be more attractive.

There are two ways in which such reduction is possible in a small farm systems context. One is by stabilizing prices through market intervention or structural change such as the introduction of a marketing board. The other is through technologies which improve yield stability.

The essential characteristics of marketing boards and how they are included in the programming model were discussed in Chapter V. Essentially, the effect of a marketing board is to produce price stabilization. Empirically, this has proved to be so successful in the case of coffee as to make it the dominant activity in Southern Huila. Yield stability, on the other hand, is a biophysical factor. Thus, it is important in technology design. Most of the current work on bean technology at the national and international centers is focused on yields alone, with little emphasis on the probability distributions of yields. Given these circumstances for bean technology design and expense involved in technology development, the ex-ante evaluation of yield stability can be important to research policy.

Assuming a reduction of 25 percent in the profit variance for the new bean technology (a figure completely arbitrary but not out of reach for biophysical scientists) and two different prices for stored beans (P_s = 36 pesos per kilogram and P_s = 40 pesos per kilogram) the results are as follows. There is a significant response to the 25 percent reduction for both farm sizes (Tables 7.4 and 7.5). This response, however, is limited to the lowest level of risk aversion (ϕ = -0.05).

Table 7.4

IMPACT OF YIELD STABILITY, MARKETING BOARDS AND STORAGE ON THE SMALL FARM IN SOUTHERN HUILA, FARM 3

	Farm Size, 15.8 Hectares					
	$\phi = -0.5$		$\phi = -0.25$		$\phi = -0.05$	
Item	$P_s = 36$	$P_s = 40$	$P_s = 36$	$P_s = 40$	$P_s = 36$	$P_s = 40$
Gross Margin (Pesos)	113,227	113,227	169,051	169,051	189,115	193,440
Crop Area (Hectares)						
New Caturra Coffee	1.38	1.38	1.87	1.87	2.16	1.53
Low Technology Caturra Coffee			0.67	0.67		1.64
Old Coffee	0.81	0.81	2.21	2.21	2.05	2.21
Beans, Better Agronomy and Storage						
First Semester					0.32	0.41
Second Semester					0.64	
Household, Pastures, and Other Activities	13.61	13.61	11.05	11.05	10.95	10.01
Labor Sales (Man Days)	180	180	168	168	--	19
Capital Borrowing (Pesos)	11,477	11,477	57,260	57,260	28,128	49,030

1.0 U.S. Dollar = 40.0 Pesos.

Table 7.5

IMPACT OF YIELD STABILITY, MARKETING BOARDS AND STORAGE ON THE SMALL FARM IN SOUTHERN HUILA, FARM 1

	Farm Size, 2.4 Hectares					
	: = -0.5		: = -0.25		: = -0.05	
Item	P_s = 36	P_s = 40	P_s = 36	P_s = 40	P_s = 36	P_s = 40
Gross Margin (Pesos)	101,535	101,535	116,142	116,142	132,926	148,268
Crop Area (Hectares)						
New Caturra Coffee	1.19	1.19	1.34	1.34	1.66	1.20
Low Technology Caturra Coffee	0.25	0.25	0.71	0.71	0.39	0.70
Old Coffee	0.34	0.34	0.34	0.34	--	0.15
Beans, Better Agronomy and Storage						
First Semester					0.34	0.08
Second Semester					0.34	0.35
Corn-Beans						0.08
Household, Pastures, and Other Activities	0.63	0.63	0.01	0.01	0.01	0.01
Labor Sales (Man Days)	88	88	62	62	29	7
Capital Borrowing (Pesos)	8,871	8,871	16,598	16,598	27,936	33,811

1.0 U.S. Dollar = 40.0 Pesos.

In the larger, 15.8 hectares, farm the presence of the new technology brings about a 12 percent increase at P_s = 36 pesos per kilogram and an increment of 14.5 percent at P_s = 40 pesos per kilogram. The area allotted to the new bean technology under storage goes from zero at $\phi = -0.5$ and $\phi = -0.25$ to 0.96 hectares at $\phi = -0.05$. At the higher price of 40 pesos per kilogram for stored beans there seems to be a negative income effect which reduces the bean area to 0.41 hectares. Another remarkable aspect of the reduced variance is the effect on labor and capital use. The presence of the new technology, an annual activity, brings about a more efficient use of family labor and a lower level of borrowed capital, despite the fact that the area in cultivation has been expanded.

The case for the 2.4 hectare farm is equally encouraging. New technology appears in the solution at the low level of risk aversion ($\phi = -0.05$), a gain in adoption over the previous results under the original variance. Assuming the new reduced variance the area in beans under Better Agronomy, storage and P_s = 36 pesos per kilogram bean production increases from zero to 0.68 hectares, or 28 percent of the farm. At a higher price of beans (P_s = 40 pesos per kilogram) the area decreases to 0.43 but income increases an additional 12 percent.

Since the small farm has little if any land left idle, the increase in bean area is at the expense of the coffee area, a fact which tends to support the assertion regarding the effectiveness of variance reducing technologies. Although capital borrowing increases significantly, family labor is more effectively utilized, as indicated by the net reduction in labor sales.

Conclusions

The evidence generated in this chapter supports the conclusion that a basic element in the technology adoption process is the farmer's perception of the probability distribution of yield from the new technology. An institutional package of credit and promotion typically associated with a new technology seems to be a necessary but not sufficient condition for adoption. When the new coffee variety, Caturra, was introduced in Huila in the early seventies the National Federation of Coffee Growers promoted it on the basis of high yields and stability of yields, accompanying the promotion with an ancilliary institutional package of guaranteed prices. It has taken them almost 10 years to have the new variety adopted totally.

In the case of beans, a crop much more susceptible to pests and the climate, the promoting effects may need to be greater. Prior experiences with coffee production and farmers' associations indicate that the concept and operation of a marketing board is not a far fetched idea. Again, the element to be studied in more detail is the distribution of yields.

Finally, these results point out one of the modifications necessary in the design of new technology. The sacrifice of higher yields in favor of stability is not new or incompatible with the research structure at the internarional centers. In fact, a formal theoretical model of yield stability has already been developed at IRRI (Evenson, O'Toole, Herdt, Coffman and Kauffman [1978]). The contribution of these results, however, relates to the inclusion of yield stability in a small farm systems context which also includes the farmer's perception of stability. The results suggest that increased emphasis on yield

stability in research design should be given if price stabilizing institutions are not to accompany the introduction of the new technologies.

CHAPTER VIII

SUMMARY AND CONCLUSIONS

Summary

In attempting to brirg the small farm systems of the developing world into the mainstream of economic activity, new technologies are constantly being developed, sometimes at a substantial cost in time and money. This attention to the small farm system is not unwarranted. Small farmers account for the vast majority of the population engaged in farming in the developing countries. Moreover, they control only a small fraction of the total arable land.

Unfortunately, past attempts to improve small farm welfare through the transfer of new technology have generally failed due to the questionable nature of the technology itself, the transfer process or both. As a consequence, attempts to generate more appropriate technologies and transfer processes are now being made, especially within the network of International Research Centers. Given the highly restrictive environment in which small farms operate, it is clear that the potential for adoption of technologies now being developed is closely linked to the institutional framework surrounding the small farm system.

In this vein, the present study has attempted to merge the new bean technology generated by the Centro Internacional de Agricultura Tropical (CIAT) and the institutional framework into a more coherent unit. Specifically, the main purpose of this study was to evaluate,

on an ex-ante basis, the potential adoption of new bean technologies with and without modifications in the institutional structure. The institutions considered related to stabilizing incomes of the small farmers.

Data for the analysis came primarily from field surveys conducted by the CIAT Bean Program in Southern Huila, Colombia, one of the sites chosen by CIAT for their on-farm technology trials, as well as from the trial results themselves. The basic methodology for this analysis was quadratic programming. The linear portion of the model was built from technical coefficients obtained from published data and adjusted by using field surveys conducted by Bean Program personnel. The quadratic portion of the risk programming model was based on risk aversion coefficients and the perceptions of crop variance generated from a survey of farmers judgmental uncertainty and attitudes toward it.

The new technology tested in the model was Improved Agronomy, as generated by CIAT. Prospective adoption was tested with and without changes in the institutional structure. The institutional variables were on-farm storage and marketing boards. The main results from this study can be summarized as follows:

a) Farmers are risk averse.

b) Risk aversion significantly affects production decisions.

c) Risk aversion has a substantial and negative effect on technology adoption.

d) The use of judgmental variance estimates for prices and yields give considerable gains in model performance.

e) Although new technology alone has an almost imperceptible

impact on farm income, the combination of technological and institutional variables does increase, albeit modestly, farm income and employment.

f) The most significant gains in technology adoption and farm income were produced by the inclusion of yield and price stability in the model.

Conclusions

The word around which this section revolves is adoption. How is it viewed, what new aspects have remained obscure, what has been gained from this study. Then the discussion focuses on the aspect of risk and factors influencing risk aversion. Finally, the discussion of research design and the associated implications for resource allocation is undertaken.

There is much to be gained by reassessing present attitudes to technology adoption. Up to this point in time, the efforts at CIAT to develop an appropriate technology for small farm systems have been mostly fruitless. The problem, as suggested by the results of this study, is that both researchers' and farmers' attitudes toward adoption have been at odds with each other. Thus, it is necessary to develop research methods which allow the identification of the discrepancies now existing between the farmers' perception of the price and yield distributions and the true price and yield distributions associated with these technologies. Moreover, it is necessary to study the discrepancies existing between the price and yield distributions associated with a new technology and their distributions. And finally, to study the discrepancies existing between the researchers' perception of the distribution for a new technology and the "real" distribution

as perceived by farmers.

As suggested by the results from this study, what has been occurring in the past is that farmers have assigned new technologies a subjective variance so high as to render it incompatible with their cropping systems. Researchers, on the other hand, have consistently ignored non-biophysical aspects of adoption and relied entirely on yield characteristics, while neglecting economic aspects of new technologies. As a consequence, there is a need for methods which allow for a better understanding of the sociological factors influencing the discrepancies in perceptions among both farmers and researchers, along with methods which allow for a reconciliation between these discrepancies and effect risk aversion.

Another key element in the study of adoption is the identification of the factors influencing adoption. It is not enough to know about attitudes toward new technologies. There are also logistical aspects of promotion, modifications of agricultural sector structure, and so forth. Based on the results from Chapters VI and VII, the factors influencing adoption are much more an effect on the objective function than the constraint set. This has far reaching policy implications. Institutional change such as land reform, or changes aimed at relaxing the constraint set (i.e., credit), are not necessary for adoption. Institutional changes affecting the elements of the objective function, on the other hand, will be more effective. These, of course, relate largely to prices and yields. But under normal conditions, an upward change in prices cannot occur without altering the market, and the market cannot be altered unless there is a change in the institutional framework. One type of change that would provoke

the increased and more stable prices is marketing board or a similar institution.

Changes in the elements of the objective function of course are not limited to the linear segment. The results from the study indicate that a large degree of success in the adoption of new technologies rests upon the quadratic elements of the objective function. Modifications allowing for a reduction in the farmers' perception of profit variance for the new technology fall within the perview of institutions for yield and price stabilization. Furthermore, there is room for farmer education programs in which true distributions of prices and yields associated with the new technology are communicated. As mentioned in Chapters V and VI, the information programs need not be expensive and can concentrate on the less risk averse farmers.

Risk Aversion

An important conclusion of this study regards the assertion that risk aversion precludes technology adoption. More important, however, is the connection established between risk aversion and the socioeconomic environment. The results shown in Chapter V suggest that aiming rural policy towards the fraction of farmers less averse to risk could bring a more rapid level of innovation and adoption. Effort should be made to help farmers acquire legal titles for their land, a legal barrier to credit, and to participate in extension programs designed to inform farmers about the true characteristics of the new technologies.

This latter aspect is of utmost importance. As evidenced by the results in Chapter V, the use of relatively modern inputs is associated with farmers who are less risk averse. Although their

personal assessment of risk may have induced them to acquire inputs, learning about the inputs themselves has a more prominent effect.[1]

Farm Models and Research Design

This section is largely a series of suggestions based on the model results. First, it is recommended that farm models similar in nature and structure to the one in this study be used in the design of economic research on the peasant farms. In particular, it is necessary to know more about the role of human capital in the design process, as well as the characteristics of the objective functions for small farmers. Other suggestions include the use of recursive models and stochastic programming. The naive efforts made in the area of judgmental distribution solicitation proved beneficial for better understanding the problem of technology adoption. These methods, however, have wide applicability in decision models or impact studies when the available time series are scanty or of a dubious nature.

Second, the emphasis on price distribution as an integral part of technology design models cannot be overstressed. The available evidence seems to indicate that international centers such as CIAT have concentrated most of their energy on biophysical aspects of new technology, with the market and price implications for the new technology relegated to a category of benign neglect. This attitude, however, is changing very rapidly. However, the suggestion generated by this study is that in terms of internal budget allocations the economic sections at the international centers allocate more effort studying the market structure and price distributions.

The third point refers to political aspects of technology design. As exemplified by the agricultural structure faced by the

peasant farmer in Southern Huila, new technology is not devoid of political implications. The policy at CIAT so far has been to generate politically inert technologies. The results from this study indicate that such technologies will not be successful in adoption and farm income improvement. Given that there is practically no room for an apolitical technology, the centers should shed this inhibition and undertake research designs more atuned to the agrarian and political structures in which the target clientele operate. Economic modeling with new technologies and institutional change should be an item of priority. This approach to technology generation would undoubtedly utilize the center's resources more efficiently.

The fourth and final point concerns the transferability of new technology from the small to big farms. Although a great deal of the urban poor would welcome an increase in the supply of cheaper food irrespective of its source, the rural poor cannot be overlooked. Hence, the emphasis on the characteristics of new technology should be placed on its appropriateness to the small farm system. The rural poor are the most numerous among the poor. So far, the new bean technologies seem to have failed the test of transferability. Efforts, however, are now being made in this direction as evidenced by the on-farm trials for 1980 which emphasize associated cropping instead of monoculture with the attention to institutions that this study has stimulated.

Research Suggestions

The suggestions for further research outlined here are a direct consequence of the limitations of this study. First of all, this is a farm level study. As such, it does not have the dynamic elements

implied by a sector model. Aggregate gains in output would undoubtedly affect the price of beans and the profitability of new technology. Such effect, due to its complexity, has been ignored. Moreover, the model does not include the economic activities of the household. The inclusion of the myriad of economic activities performed by household members (i.e., raising and tending livestock, crafts, schooling, hunting, etc.) would be a welcome improvement. Finally, a more formal incorporation of the marketing process, including a household consumption function and a more adequate implementation of the marketing alternatives would yield significant benefits in model performance and improved policy implications for technology design and adoption programs.

FOOTNOTES

CHAPTER VIII

[1]A TSLS regression aimed to account for this simultaneous effect yielded results almost identical to the OLS model in Table 5.3.

APPENDIX A

TABLE A-2.1

VARIABLE COST OF PRODUCTION PER HECTARE OF BEANS IN SOUTHERN HUILA, BETTER AGRONOMY TECHNOLOGY

Item	Unit	Quantity	Cost Per Unit (Pesos)	Total (Pesos)	Man Days Per Quarter First Quarter	Man Days Per Quarter Second Quarter
Land Preparation and Planting						
Machine Hire	Ha.	1	3,000	3,000		
Seed	Kg.	90	30	2,700		
Weedings (2)	Man Days		150	4,500	30	
Pest Control	Man Days			1,366		
Application	Man Days		150	300		2
Harvest						
Beans, 1,561 Kg.	Man Days		150	4,500		30
Threshing	Man Days		150	1,500		10
Subtotal				17,716		
Other Expenses (5%)				885		
Total				18,601		
Total Labor Cost				10,450	—	—
Total Cost Excluding Labor				8,151	30	42

TABLE A-2.2

COST OF STORAGE OF ONE HECTARE OF BEANS UNDER CURRENT LEVELS OF TECHNOLOGY IN SOUTHERN HUILA

Item	Unit	Quantity	Cost Per Unit	Total
Subtotal from Bean Production Technology				3,727.5
Steel Drums (depreciated at 5 years)		6	90	540.0
Cooking Oil	450 cc	2,700	27	162.0
Labor	Man Day	6	150	900.0
Interest			6%	1,267.0
Total Input Cost				6,596.0

TABLE A-3.1

VARIABLE COST OF PRODUCTION PER HECTARE OF COFFEE FOR SOUTHERN HUILA (PESOS PER HECTARE)

YEAR 1

Item	Unit	Quantity	Cost Per Unit (Pesos)	Total (Pesos)	Man Days per Quarter First Quarter	Man Days per Quarter Second Quarter
Nursery	Seedlings	4,000	2	8,000		
Land Preparation	Man Days		150	4,800	32	
Establishment of "Platano"	Seedlings	400	6	2,400		
a) Disinfection	Man Days		150	150	1	
Malathion	Lts.	0.5	177	88		
Dithane	Kg.	0.5	100	50		
Alcohol	Lts.	5	32	160		
b) Planting and Fertilizing	Man Days		150	1,500	10	
Establishment of Coffee						
a) Tracing of Holes	Sticks	800	0.25	200		
b) Planting	Man Days		150	3,000	20	
			150	5,550		37
Fertilizer for Coffee						
Urea	Kg.	60	10	600		
Chicken Manure	Kg.	2,000	1.5	3,000		
Application	Man Days		150	900		6
Fertilizer for Coffee						
12-12-17-2	Kg.	30	9.8	294		
Pest Control (every 45 days)						
Benlate	Kg.	1	1,100	1,100		
Application	Man Days		150	600		4
Total Man Days Per Quarter					63	47
					Third Quarter	Fourth Quarter
Weeding	Man Days		150	2,100	14	
			200	3,600		18
Replanting (8%)	Seedlings	320	2	640		
	Man Days		200	2,000		10
Maintenance of "Plataao"	Man Days		150	600	4	
	Man Days		200	800		4
Coffee Fertilization						
Urea	Kg.	400	100	4,000		
Application	Man Days		150	1,200	8	
Weeding and Clearing	Man Days		150	750	5	
	Man Days		200	1,000		5
Pest Control, Coffee (every 45 days)						
Benlate	Kg.	2	1,100	2,200		
Liquid Urea	Kg.	6	10	60		
Application	Man Days		150	300	2	
	Man Days		200	600		4
Total Man Days Per Quarter					33	41
Sprayer Pump (depreciated linearly for 5 years)		1	3,800	760		
Subtotal				53,202		
Other Expenses (5%)				2,660		
				55,862		
Total Labor Costs				29,650		
Total Cost Excluding Labor				26,212		

TABLE A-3.1--Continued

YEAR 2

Item	Unit	Quantity	Cost Per Unit (Pesos)	Total (Pesos)	Man Days per Quarter First Quarter	Man Days per Quarter Second Quarter
Weeding	Man Days		150	2,100	14	
Fertilization of Coffee	Man Days		150	2,100		14
Urea	Kg.	600	10	6,000		
Application	Man Days		150	600	4	
	Man Days		150	600		4
Maintenance of "Platano"	Man Days		150	600	4	
Weed Clearing With Machete	Man Days		150	750	5	
	Man Days		150	750		5
Pest Control of Coffee						
Benlate	Kg.	1.5	1,100	1,650		
Urea	Kg.	6	10	60		
Application	Man Days		150	450	3	
	Man Days		150	450		3
Total Man Days Per Quarter					30	26
					Third Quarter	Fourth Quarter
Weeding	Man Days		150	2,100	14	
	Man Days		200	2,800		14
Fertilization of Coffee						
12-12-7-2	Kg.	600	8.8	5,880		
Application	Man Days		150	600	4	
	Man Days		200	800		4
Maintenance of "Platano"	Man Days		150	600	4	
Weed Clearing With Machete	Man Days		150	750	5	
	Man Days		200	1,000		5
Pest Control of Coffee						
Benlate	Kg.	2	1,100	2,200		
Application	Man Days		150	450	3	
	Man Days		200	600		3
Total Man Days Per Quarter					30	26
Sprayer Pump (15 year depreciation)		1	3,800	760		
Subtotal				34,650		
Other Expenses (5%)				1,732.5		
				36,382.5		
Total Labor Costs				18,100		
Total Excluding Labor				18,282.5		

TABLE A-3.1--Continued

YEAR 3

Item	Unit	Quantity	Cost Per Unit (Pesos)	Total (Pesos)	Man Days per Quarter First Quarter	Man Days per Quarter Second Quarter
Weeding	Man Days		150	2,100	14	
Fertilization of Coffee and "Platano", Weed Clearing						
With Machete	Man Days		150	750	5	
12-12-17-2	Kg.	860	9.8	8,428		
Application	Man Days		150	750	5	
Maintenance of "Platano"	Man Days		150	600		4
Pest Control						
Benlate	Kg.	2	1,100	2,200		
Application	Man Days		150	300	2	
Total Man Days Per Quarter					26	4
					Third Quarter	Fourth Quarter
Weeding	Man Days		150	2,100	14	
Fertilization of Coffee and "Platano"						
12-12-17-2	Kg.	860	9.8	8,428		
Application	Man Days		150	750	5	
Weed Clearing With Machete	Man Days		150	750	5	
Maintenance of "Platano"	Man Days		150	600	4	
Pest Control						
Benlate	Kg.	2	1,100	2,200		
Application	Man Days		150	300	2	
Harvest						
"Platano", 400 Bunches	Man Days		150	900	6	
Coffee, 1,125 Kg.	Man Days		200	14,200		71
Total Man Days Per Quarter					36	71
Sprayer Pump				760		
Subtotal				46,116		
Other Expenses (5%)				2,305.8		
				48,421.8		
Total Labor Costs				-24,100		
Total Cost Excluding Labor				24,321.8		

TABLE A-3.1--Continued

YEAR 4

Item	Unit	Quantity	Cost Per Unit (Pesos)	Total (Pesos)	Man Days Per Quarter First Quarter	Man Days Per Quarter Second Quarter
Weeding	Man Days		150	1,800	12	
Fertilization of Coffee and "Platano"						
12-12-17-2	Kg.	660	9.8	6,468		
Application	Man Days		150	750	5	
Weed Clearing With Machete	Man Days		150	750	5	
Maintenance of "Platano"	Man Days		150	600	4	
Pest Control of "Platano"						
Benlate	Kg.	0.7	1,100	770		
Application	Man Days		150	150	1	
Total Man Days Per Quarter					27	
					Third Quarter	Fourth Quarter
Weeding	Man Days		150	2,550	17	
Fertilization of Coffee and "Platano"						
12-6-22-2	Kg.	660	9.8	6,468		
Application	Man Days		150	750	5	
Maintenance of "Platano"	Man Days		150	600	4	
Pest Control of "Platano"						
Benlate	Kg.	0.7	1,100	770		
Application	Man Days		150	150	1	
Harvest						
"Platano", 800 Bunches	Man Days		150	900	6	
	Man Days		200	1,200		6
Coffee, 2,000 Kg.	Man Days		200	26,600		133
Total Man Days Per Quarter					33	139
Sprayer Pump				760		
Subtotal				52,036		
Other Expenses (5%)				2,601.8		
				54,637.8		
Total Labor Costs				36,800		
Total Cost Excluding Labor				17,837.8		

TABLE A-3.1--Continued

Item	Unit	Cost Per Unit (Pesos)	Total (Pesos)	Man Days Per Quarter Third Quarter	Man Days Per Quarter Fourth Quarter
YEAR 5					
Same as Year 4 Except:					
Subtotal for Year 4 (excluding harvest cost for coffee)			22,576	27	
Harvest					
"Platano", 800 Bunches	Man Days	150	900	6	
	Man Days	200	1,200		6
Coffee, 2,275 Kg.	Man Days	200	30,000		150
Subtotal			54,676		
Other Expenses (5%)			2,733.8		
Total			57,409.8		
Subtotal Labor Costs Year 4 ($8,100) + Harvest Labor Year 5			40,200	—	—
Total Cost Excluding Labor			17,209.8	33	156
YEAR 6				Third Quarter	Fourth Quarter
Subtotal From Year 4			22,576	27	
Harvest:					
"Platano", 800 Bunches	Man Days	150	900	6	
	Man Days	200	1,200		6
Coffee, 2,150 Kg.	Man Days	200	29,800		149
Subtotal			54,476		
Other Expenses (5%)			2,723.8		
Total			57,199.8		
Subtotal Labor Costs Year 4 ($8,100) + Harvest Labor Year 6			40,000	—	—
Total Cost Excluding Labor			17,199.8	33	155

TABLE A-3.1--Continued

Item	Unit	Cost Per Unit (Pesos)	Total (Pesos)	Man Days Per Quarter Third Quarter	Fourth Quarter
YEAR 7					
Subtotal From Year 4			22,576	27	
Harvest					
"Platano", 800 Bunches	Man Days	150	900	6	
	Man Days	200	1,200		6
Coffee, 1,750 Kg.	Man Days	200	23,400		117
Subtotal			48,076		
Other Expenses (5%)			2,403.8		
Total			50,479.8		
Subtotal Labor Cost Year 4 ($8,100) + Harvest Labor Year 7			33,600	—	—
Total Cost Excluding Labor			16,879.8	33	123
YEAR 8				Third Quarter	Fourth Quarter
Subtotal From Year 4			22,576	27	
Harvest					
"Platano", 800 Bunches	Man Days	150	900	6	
	Man Days	200	1,200		6
Coffee, 1,500 Kg.	Man Days	200	20,000		100
Subtotal			44,676		
Other Expenses (5%)			2,233.8		
Total			46,909.8		
Subtotal Labor Cost Year 4 ($8,100) + Harvest Labor Year 8			30,200	—	—
Total Cost Excluding Labor			16,709.8	33	106

TABLE A-3.1--Continued

YEARS 9-12					
				Man Days Per Quarter	
Item	Unit	Cost Per Unit (Pesos)	Total (Pesos)	Third Quarter	Fourth Quarter
Subtotal From Year 4			22,576	27	
Harvest					
"Platano", 800 Bunches	Man Days	150	900	6	
	Man Days	200	1,200		6
Coffee, 1,250 Kg.	Man Days	200	16,600		83
Subtotal			41,276		
Other Expenses (5%)			2,063.8		
Total			43,339.8		
Subtotal Labor Cost Year 4 + Harvest Labor Years 9-12			26,800	---	---
Total Cost Excluding Labor			16,539.8	33	89

TABLE A-3.2

VARIABLE COST OF PRODUCTION PER HECTARE OF COFFEE FOR SOUTHERN HUILA (PESOS PER HECTARE), OLD COFFEE OR CATURRA COFFEE UNDER LOW LEVELS OF TECHNOLOGY[a]

Item	Unit	Cost Per Unit	Total (Pesos)	Man Days Per Quarter: First Quarter	Man Days Per Quarter: Second Quarter
Weeding	Man Days	150	1,800	12	
Maintenance and Harvest of "Platano", 150 Bunches	Man Days	150	600	4	
	Man Days	150	600		4
				16	4
				Third Quarter	Fourth Quarter
Weeding	Man Days	150	1,800	12	
Harvest					
"Platano", 150 Bunches	Man Days	150	600	4	
	Man Days	200	800		4
Coffee, 400 Kg. (466 for caturra under low technology)	Man Days	200	6,000		30
Subtotal			12,200	16	34
Other Expenses (5%)			610		
Total			12,810		
Labor Cost			-12,000		
Total Cost Excluding Labor			810		

[a]Caturra coffee under low levels of technology is defined as coffee grown under high technology during the first two years of crop life and under minimal care during the remaining production years.

TABLE A-3.3

VARIABLE COST OF PRODUCTION PER HECTARE OF SUGARCANE FOR SOUTHERN HUILA

Item	Unit	Quantity	Cost Per Unit (Pesos)	Total (Pesos)	Man Days Per Quarter First Quarter	Second Quarter
YEAR 1						
Land Preparation						
Clearing and Hoe Plowing	Man Days		150	3,750	25	
Planting	Man Days		150	1,500	10	
Sugarcane Seed	Kg.	6,250	0.8	5,000		
Weedings	Man Days		150	2,550	35	17
					Third Quarter	Fourth Quarter
Weeding	Man Days		150	2,550	17	16
Subtotal				15,350		
Other Expenses (5%)				767.5		
Total				16,117.5		
Total Labor Cost				10,350	—	—
Total Cost Excluding Labor				5,767.5	17	16
YEAR 2						
					First Quarter	Second Quarter
Harvest 4 375 Kg. of Brown Sugar						
Cutting	Man Days		150	1,500	10	
	Man Days		200	2,000		10
Milling	Man Days		150	2,250	15	
	Man Days		200	3,000		15
Mill Rent	Kg.	4,375	0.92	4,025		
Subtotal				12,775		
Other Expenses (5%)				638.8		
Total				13,413.8		
Total Labor Costs				8,750	—	—
Total Cost Excluding Labor				4,663.8	25	25
YEAR 3						
					First Quarter	Second Quarter
Clearing, Weeding and Replanting	Man Days		150	3,000	20	
					Third Quarter	Fourth Quarter
Harvest 3,062 Kg. of Brown Sugar						
Cutting	Man Days		150	1,500	10	
	Man Days		200	2,000		10
Milling	Man Days		150	1,800	12	
	Man Days		200	2,400		12
Mill Rent	Kg.	3,750	0.92	3,450		
Subtotal				14,150		
Other Expenses (5%)				707.5		
Total				14,857.5		
Total Labor Cost				10,700	—	—
Total Cost Excluding Labor				4,157.5	22	22

TABLE A-3.4

VARIABLE COST OF PRODUCTION PER HECTARE OF CASSAVA
IN SOUTHERN HUILA, YEAR 1

Item	Unit	Cost Per Unit (Pesos)	Total (Pesos)	Man Days Per Quarter First Quarter	Man Days Per Quarter Second Quarter
Land Preparation					
Slash, Burn and Hoe Plowing	Man Days	150	1,950	13	
Planting	Man Days	150	900	6	
Cassava Seed, 6,600 Seedlings	Man Days	150	300	2	
Weeding	Man Days	150	4,200		28
				Third Quarter	Fourth Quarter
Weeding	Man Days	150	1,500	10	
Subtotal			8,850		
Other Expenses (5%)			442.5		
Total			9,292.5		
Total Labor Costs			8,850		
Total Cost Excluding Labor			442.5		
				Third Quarter	Fourth Quarter
Harvest, 8,000 Kg.	Man Days	150	900	6	
	Man Days	200	1,200		6
Subtotal			2,100		
Other Expenses (5%)			105		
Total			2,205		
Total Labor Costs			2,100		
Total Cost Excluding Labor			105		

TABLE A-3.5

VARIABLE COST OF PRODUCTION PER HECTARE OF ONION
IN SOUTHERN HUILA

Item	Unit	Quantity	Cost Per Unit (Pesos)	Total (Pesos)	Man Days Per Quarter First Quarter	Man Days Per Quarter Second Quarter
YEAR 1						
Land Preparation						
Clearing and Hoe Plowing	Man Days		150	6,000	40	
Planting						
Seed	Kg.	5,000	7	35,000		
Seed Preparation	Man Days		150	3,000	20	
Planting	Man Days		150	6,000	40	
Drainage	Man Days		150	750	5	
Weedings (3)	Man Days		150	2,400	16	
	Man Days		150	4,800		32
Fertilization and Pest Control						
10-30-10	Kg.	450	10.4	4,680		
EPN	Lt.	4	245	980		
Dithane	Kg.	1	100	100		
Application	Man Days		150	600	4	
	Man Days		150	1,200	4	8
					125	40
Sprayer Pump (depreciated at 5 years)		1	3,800	760		
					Third Quarter	Fourth Quarter
Picking and Packing, 6,250 Kg.	Man Days		150	1,800	12	
	Man Days		200	2,400		12
Subtotal				70,470		
Other Expenses (5%)				3,523.5		
Total				73,993.5		
Total Labor Costs				28,950	—	—
Total Cost Excluding Labor				45,043.5	12	12
YEARS 2-5						
					First Quarter	Second Quarter
Weedings (2)	Man Days		150	1,800	12	
	Man Days		150	1,800		12
Fertilization and Pest Control (Same as Year 1)				7,720	4	8
Harvest, 6,250 Kg.	Man Days		150	1,800	12	
	Man Days		150	1,800	—	12
					28	32
					Third Quarter	Fourth Quarter
Weedings	Man Days		150	1,800	12	
	Man Days		200	2,400		12
Harvest, 6,250 Kg.	Man Days		150	1,800	12	
	Man Days		200	2,400		12
Subtotal				23,320		
Other Expenses (5%)				1,166		
Total				24,486		
Total Labor Cost				15,600	—	—
Total Cost Excluding Labor				3,886	24	24

TABLE A-3.6

VARIABLE COST OF PRODUCTION PER HECTARE OF TOMATOES
IN SOUTHERN HUILA

Item	Unit	Quantity	Cost Per Unit (Pesos)	Total (Pesos)	Man Days Per Quarter First Quarter	Man Days Per Quarter Second Quarter
Land Preparation						
Machine Hire	Ha.	1	3,000	3,000		
Planting (including nursery labor)	Man Days		150	3,750	25	
Seed	Oz.	7.15	85	608		
Drainage	Man Days		150	1,500	10	
Weedings (3)	Man Days		150	1,500	10	
	Man Days		150	3,000		20
Support System						
Bamboo Posts (depreciated at 2 years)	8' Logs	143	20	1,430		
Canes (depreciated at 2 years)	6' Sticks	6,000	0.6	1,800		
Tin Wire (depreciated at 9 years)	M.	7,500	2.78	2,222		
Rope	M.	30,000	0.04	1,250		
Tying and Supporting Labor	Man Days		150	12,000		80
Irrigation by Hand	Man Days		150	5,250		35
Fertilization						
14-14-14	Kg.	715	10.3	7,365		
12-26-6	Kg.	715	11.1	7,937		
Lime	Kg.	285	2.3	656		
Application	Man Days		150	1,500		10
Pest Control						
Manzate	Kg.	10	102	1,020		
Nudrex	Lt.	10	103	1,030		
Application (10)	Man Days		150	300	2	
	Man Days		150	1,200		8
Harvest, 1,875 Boxes of 14.6 Kg. each of 27,500 Kg.	Man Days		150	10,500		70
Packing	Man Days		150	5,250		35
Boxes		1,875	15.02	28,165		
Sprayer Pump (depreciated at 5 years)		1	3,800	760		
Subtotal				102,993		
Other Expenses (5%)				5,149.7		
Total				108,142.7		
Total Labor Costs				45,750		
Total Cost Excluding Labor				62,392.7	47	258

TABLE A-3.7

VARIABLE COST OF PRODUCTION PER HECTARE OF BEANS-MAIZE SYSTEM
IN SOUTHERN HUILA, LOCAL TECHNOLOGY LEVEL 1

Item	Unit	Quantity	Cost Per Unit (Pesos)	Total (Pesos)	Man Days Per Quarter First Quarter	Man Days Per Quarter Second Quarter
Land Preparation						
Machine Hire	Ha.	1	3,000	3,000		
Planting						
Corn	Man Days		150	450	3	
Beans, Machine Hire	Ha.	1	300	300		
Corn Seed	Kg.	30	8	240		
Bean Seed	Kg.	60	30	1,800		
Weedings (2)	Man Days		150	3,000	20	
Fertilization						
10-30-10	Kg.	250	10.4	2,600		
Application	Man Days		150	600	4	
Harvest						
Beans, 625 Kg.	Man Days		150	3,600		24
Maize, 1,875 Kg.						
Threshing	Man Days		150	1,050		7
Subtotal				16,640		
Other Expenses (5%)				832		
Total				17,472		
Total Labor Cost				8,700	—	—
Total Cost, Excluding Labor				8,772	27	31

TABLE A-3.8

VARIABLE COST OF PRODUCTION PER HECTARE OF BEANS-MAIZE SYSTEM
IN SOUTHERN HUILA, LOCAL TECHNOLOGY LEVEL 2

Item	Unit	Quantity	Cost Per Unit (Pesos)	Total (Pesos)	Man Days Per Quarter First Quarter	Man Days Per Quarter Second Quarter
Land Preparation						
Clearing and Hoe Plowing	Man Days		150	2,400	16	
Planting	Man Days		150	1,800	12	
Corn Seed	Kg.	25	8	200		
Bean Seed	Kg.	60	30	1,800		
Weedings (2)	Man Days		150	3,000		20
Harvest						
Beans, 500 Kg.						
Maize, 800 Kg.	Man Days		150	3,000		20
Threshing	Man Days		150	1,500		10
Subtotal				13,700		
Other Expenses (5%)				685		
Total				14,385		
Total Labor Cost				11,700	---	---
Total Cost Excluding Labor				2,685	28	50

TABLE A-3.9

VARIABLE COST OF PRODUCTION PER HECTARE OF BEANS-MAIZE SYSTEM
IN SOUTHERN HUILA, LOCAL TECHNOLOGY LEVEL 3

Item	Unit	Quantity	Cost Per Unit (Pesos)	Total (Pesos)	Man Days Per Quarter First Quarter	Man Days Per Quarter Second Quarter
Land Preparation						
Machine Hire	Ha.		3,000	3,000		
Planting	Man Days		150	450	3	
Corn	Man Days					
Beans, Machine Hire	Ha.	1	300	300		
Corn Seed	Kg.	25	8	200		
Bean Seed	Kg.	60	30	1,800		
Weedings (3)	Man Days		150	1,500	10	
	Man Days		150	3,000		20
Fertilization						
10-30-10	Kg.	250	10.4	2,600		
Application	Man Days		150	600	4	
Pest Control						
Dipterex 80	Kg.	0.4	18	7		
Malathion	Kg.	0.8	177	142		
Application	Man Days		150	300		2
Harvest						
Corn, 1,300 Kg.	Man Days		150	1,500		10
Beans, 800 Kg.						
Threshing	Man Days		150	1,500		10
Sprayer Pump (at 5 year depreciation)		1	3,800	760		
Subtotal				17,659		
Other Expenses (5%)				883		
Total				18,542		
Total Labor Cost				8,850	—	—
Total Cost Excluding Labor				9,692	17	42

TABLE A-3.10

VARIABLE COST OF PRODUCTION PER HECTARE OF BEANS
IN SOUTHERN HUILA, LOCAL TECHNOLOGY LEVEL 1

Item	Unit	Quantity	Cost Per Unit (Pesos)	Total (Pesos)	Man Days Per Quarter First Quarter	Man Days Per Quarter Second Quarter
FIRST SEMESTER						
Land Preparation and Planting						
Clearing	Man Days		150	1,800	12	
Planting	Man Days		150	3,000	20	
Seed	Kg.	100	30	3,000		
Weedings (2)	Man Days		150	3,000		20
Harvest, 860 Kg.	Man Days		150	3,000		20
Threshing	Man Days		150	750		5
Subtotal				14,550		
Other Expenses (5%)				727.5		
Total				15,277.5		
Total Labor Cost				11,550	—	—
Total Cost Excluding Labor				3,727.5	32	45
SECOND SEMESTER						
					Third Quarter	Fourth Quarter
Subtotal From First Semester				10,800	32	
Harvest, 662 Kg.	Man Days		200	3,400		17
Threshing	Man Days		200	600		3
Subtotal				14,800		
Other Expenses (5%)				740		
Total				15,540		
Total Labor Cost				11,800	—	—
Total Cost Excluding Labor				3,740	32	20

TABLE A-3.11

VARIABLE COST OF PRODUCTION PER HECTARE OF BEANS
IN SOUTHERN HUILA, LOCAL TECHNOLOGY LEVEL 2

Item	Unit	Quantity	Cost Per Unit (Pesos)	Total (Pesos)	Man Days Per Quarter First Quarter	Man Days Per Quarter Second Quarter
Land Preparation and Planting						
Hired Machinery	Ha.	1	3,000	3,000		
Seed	Kg.	80	30	2,400		
Weedings (2)	Man Days		150	3,900		26
Fertilization						
Urea	Kg.	157	10	1,570		
10-30-10	Kg.	157	10.4	1,633		
Application	Man Days		150	300		2
Pest Control						
Dithane (0 manzate)	Kg.	2	100	200		
Metasistox	Oz.	8	7.5	60		
Applications (2)	Man Days		150	300		2
Harvest						
Beans, 1,270 Kg.	Man Days		150	3,750		25
Threshing	Man Days		150	1,050		7
Other Expenses						
Sprayer Pump (depreciated at 5 years)		1	3,800	760		
Subtotal				18,923		
Other Expenses (5%)				946.2		
Total				19,869.2		
Total Labor Costs				9,300		—
Total Cost Excluding Labor				10,569.2		62

APPENDIX B

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I. The Coin Game

Q. What would you prefer:

a) a fixed and certain income of 3.75 pesos
b) a bet, to be decided by a coin toss, which gives you 7 pesos if you win the toss or 0.5 pesos if you lose.

If the farmer prefers (a), decrease its value in succession until he becomes indifferent between (a) and (b).

The derivation of the risk coefficient is as follows:

Assuming the utility of income is represented by

$$U(X) = E(X) + \phi V$$

where X is a risky alternative with an expected value of E(X), a deviation V and a risk coefficient ϕ, then indifference between two income alternatives (a) and (b) implies that

$$U(A) = U(B)$$

Let $U(A) = E(a) + \phi V$

$$U(A) = 3.75 + \phi 0$$

$$U(A) = 3.75$$

and $U(B) = E(b) + \phi V$

$$U(B) = 0.5(7) + 0.5(0.5) + \phi\{0.5[E(b) - 7]^2 + 0.5[E(b) - 0.5)^2]\}^{1/2}$$

$$U(B) = 3.75 + \phi(3.25)$$

Then, if an income $a \pm \delta$ is chosen as indifferent to U(B) the risk coefficient ϕ can be calculated from the equation

$$(a \pm \delta) = 3.75 + \phi(3.25)$$

or $$\phi = \frac{(a \pm \delta) - 3.75}{3.25}$$

II. The Game of Subsistence at Risk

Q. What would you prefer:

a) a property which gives you a certain and fixed income of Y_F per month
b) a property which 3 out of 4 years gives you an income of Y_1 per month and 1 out of 4 years gives you an income of Y_2 per month.

In this game the income alternatives (a) and (b) vary according to the income needs of the farmer being interviewed. This way it is assured that a closer real world situation is being considered. Again U(A) is the amount being used as a measuring rule, thus being the "fixed income" proposition $U(A) = E(A) + \phi.0$. The risky alternative (b) is:

$$U(B) = E(b) + \phi V$$

$$U(B) = 0.75(Y_1) + 0.25(Y_2) + \phi\{0.75[E(b) - Y_1]^2 + 0.25[E(b) - Y_2]^2\}^{1/2}$$

where Y_1 and Y_2 are the income components of the risky alternative (b). Hence,

$$U(B) = 0.75Y_1 + 0.25Y_2 + \phi\{0.75[0.75Y_1 + 0.25Y_2 - Y_1]^2 + 0.25[0.75Y_1 + 0.25Y_2 - Y_2]^2\}^{1/2} = 0.75Y_1 + 0.25Y_2 + \phi z$$

where

$$z = \{0.75[-0.25Y_1 + 0.25Y_2]^2 + 0.25[0.75Y_1 - 0.75Y_2]^2\}^{1/2}$$

and therefore,

$$\phi = \frac{(a + \delta) - E(b)}{z}$$ for the risk preferers and

$$\phi = \frac{(a - \delta) - E(b)}{z}$$ for the risk averters.

III. The Game of Subsistence Assured

Q. What would you prefer:

a) a property which guarantees you your family's sustenance plus a certain and fixed income of Y_F per month
b) a property which guarantees you your family's sustenance but gives you an income of Y_1 per month 3 out of 4 years and Y_2 per month 1 out of 4 years.

This game guarantees the farmer food and shelter for him and

his family. The risk involves only income needed for expenditures other than food and shelter. In this case the income alternatives are:

$$U(A) = S + Y_F$$

$$U(B) - 0.75(S + Y_1) + 0.25(S + Y_2) + \phi\{0.75[E(b) - S - Y_1]^2 + 0.25[E(b) - S - Y_2]^2\}^{1/2}$$

and

$$\phi = \frac{(S + Y_F \pm \delta) - E(b)}{z}$$

where Y_F, Y_1, and Y_2 are the income levels associated with the game and z the expression derived on the subsistence-at-risk game.

APPENDIX C

The following questioning procedure, as adapted from Jackson[1] and further modified by Chin and Johnson,[2] was used to obtain subjective price and yield distributions from Southern Huila farmers. Although the wording may appear succinct and businesslike the actual questioning was performed by the author, who was already acquainted with the farmers interviewed.

Questioning Process

After the customary preliminary talk and explanation for the interview the questioning is patterned as follows:

Q. I am going to ask you questions based on bets of 100 pesos. You understand of course that this is hypothetical. The purpose is of course to use the bet as an aid in obtaining your perception of farm product prices and yields. I will ask you questions regarding whether you would take a 100 pesos bet that the _____ of _____ will be above or below _____. Let's start.

Note to Questioner: If the farmer is familiar with the quantity or price in question, start with a "reasonable" reference value. If not, or if the farmer appears bothered by the process initially choose some "unreasonable" reference values to help elicit clear-cut yes or no answers. The questioning should continue until the subject cannot distinguish between the two bets based on a reference value.

Q. Consider the _____ (price or quantity) of _____ for the _____ semester of 197_. Choose between two bets of 100 pesos. The first bet pays you 100 pesos if the _____ is above _____ (reference value) for the _____ semester of 197_. The second bet will pay 100 pesos if the _____ is below _____ (same reference value) for that same semester.

Note to Questioner: After the answer, move the reference value in the direction of the farmer's choice. Use your judgment about how far to move the reference value. Generally, you would like to put it high (low) enough to change the farmer's preference for the bets on being above or below the selected value.

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[1] B.B. Jackson, "Assessing Probability Distribution for Uncertain Quantities," Bulletin 9-174-193, Harvard Business School, Boston, Massachusetts, 1974.

[2] Sean B. Chin, and S.R. Johnson, "Assessment of Judgmental Input for Forecasting Model," University of Missouri-Columbia, 1978.

Q. Now consider a second set of bets, structured as were the initial set but with the new reference value of _____. Do you choose the one paying 100 pesos if the _____ (price or quantity) falls below _____ (reference value) or the one paying the 100 pesos if the _____ (price or quantity) goes above the reference value?

Note to Questioner: When you have proceeded in this manner until the farmer cannot distinguish between the referenced bets, you have isolated an indifference point. In this case it will identify the 0.50 fractile. Do not be afraid to tell the farmer what you are doing. In the next and subsequent sets of bets it is very important that you make it clear that you are considering _____ (price or quantity) in excess of, between, or below specified values. Again, use your judgment on the new reference value. Two important problems should be indicated at this point. First, the farmer may intentionally or unintentionally give inconsistent choices of the two reference bets as the associated reference value is moved around. If so, indicate that the choices are inconsistent. Moreover, some probing in connection with the consistency of choices by re-asking questions with similar reference values may be useful. Secondly, when giving the farmer the intervals for choice it is important to emphasize that you are assuming that the _____ (price, quantity) is contained in the relevant interval and not on the floor or ceiling of the specified interval.

Q. Assume that we know that the _____ (price, quantity) cannot be above _____ (0.5 fractile reference point) during the same quarter we have been discussing. Consider two bets, each paying 100 pesos. The first pays 100 pesos if the (price, quantity) is below _____ (a new reference value). The second pays 100 pesos if the _____ (price, quantity) is between the reference value of _____ and _____ (the 0.5 fractile reference value). Which of the two bets do you choose?

Note to Questioner: Move the reference value in the direction of the farmer's choice and ask same question again but related to the new reference value. Continue the process until the farmer has reached the point of indifference between sets. When this point has been reached, the 0.25 fractile reference value has been obtained. Then move to obtain the 0.75 fractile by changing the interval of focus to the 0.5 fractile and above.

Q. Now consider a _____ (price, quantity) floor at _____ (0.5 fractile reference value). Consider two new bets. One pays 100 pesos if the _____ (price, quantity) is between _____ (the new reference value) and the floor _____ (price, quantity) of _____ (0.5 fractile reference value). The second pays 100 pesos if the _____ (price, quantity) is above the new reference value of _____.

Note to Questioner: Sequence is continued until the farmer has reached a value at which he is indifferent between the two bets. This will be the reference value for the 0.75 fractile. The same process can be used to obtain reference value for the 0.125 and 0.875

fractiles by changing the _____ (price, quantity) floors or upper limits as the case may be. After you have obtained the fractile values it is important to ask a final question to establish some upper and lower bounds for the process. Go a reasonable distance away from the mean _____ (price, quantity) of the commodity in question and ask the following question:

Q. What are the lowest and highest _____ (price, quantity) you have observed for this product on your farm?

This completes the experiment.

APPENDIX D

Table D.1

VARIABLE CODE FOR RESOURCE CONSTRAINTS

Row Symbol		Resource Constraint	Unit
LDN_{ij}	i = land type = 1, 2, 3	Land	Hectares
	j = semester = 1, 2		
RLB_i	i = trimester = 1, ..., 4	Required Labor	Man Days
HLB_i	i = trimester = 1, ..., 4	Hired Labor	Man Days
FLB_i	i = trimester = 1, ..., 4	Family Labor	Man Days
OPK_i	i = trimester = 1, 2	Operating Capital	Pesos
TR (Activity Name)$_i$	i = semester = 1, 2	Transfer Rows	Kg.
PRK1, PRK2		Capital Available Per Cropping Activity	
		Private Sources	
		First and Second Semester	Pesos
K1PB, K2PB		Capital Available Per Cropping Activity	
		Institutional Sources	
		First and Second Semester	Pesos
LIMIT		Total Borrowing Capacity	Pesos

Table D.2

VARIABLE CODE FOR ACTIVITIES

Column Symbol		Variable Name
		Growing Activities
COF_i	i = land type = 1, 2, 3	High Technology Caturra Coffee
$MCOF_i$	i = land type = 1, 2, 3	Old Coffee
$LTCOF_i$	i = land type = 1, 2, 3	Low Technology Caturra Coffee
SUG_i	i = land type = 1, 2, 3	Sugarcane
CAS_i	i = land type = 1, 2, 3	Cassava
TOM_j	j = land type = 1, 2	Tomatoes
ONS_i	i = land type = 1, 2, 3	Onions
B_{hji}	h = technology = 1, 2	Beans (Current Technologies)
	j = semester = 1, 2	
	i = land type = 1, 2, 3	
BE_{ji}	j = semester = 1, 2	Beans (CIAT Technologies)
BS_{ji}	i = land type = 1, 2, 3	
CB_{hji}	h = technology = 1, 2, 3	Corn-Beans
	j = first semester	
	i = land type = 1, 2, 3	
GRSS1, GRSS2		Pasture Production
		Labor Activities
$BYLB_i$	i = trimester = 1, ..., 4	Labor Hiring
$SLLB_i$	i = trimester = 1, ..., 4	Labor Selling
$FMLB_i$	i = trimester = 1, ..., 4	Family Labor
		Selling Activities
SL (Activity Name)$_i$	i = semester = 1, 2	Product Selling
		Borrowing Activities
BNK_i	i = semester = 1, 2	Institutional (Formal) Lending
$PRLN_i$	i = semester = 1, 2	Private (Informal) Lending
TRK12		
TRK23		Capital Transfer
TRK34		Between Quarters

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