ECONOMIC EVALUATION OF BEAN-RESEARCH INVESTMENT IN MEXICO

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A DISSERTATION

Submitted to
Michigan State University
in partial fulfillment of the requirements
for the degree of

DOCTOR OF PHILOSOPHY

Department of Agricultural Economics

2003

ABSTRACT

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In Mexico, dry beans are the second most important crop after maize, both in terms of production and consumption. Approximately 85% of the country's bean crop is grown under rainfed conditions. During the 1990s, the total harvested bean area decreased by 2.0%, average yield decreased by 2.5%, and production declined by 4.5%. As a result, there has been an increasing trend in requiring bean imports to meet domestic demand, especially after Mexico joined NAFTA in 1994. During the 1990s the Mexican government, through the Secretariat of Agriculture (SAGAR), started two programs—PROCAMPO and Alliance for the Countryside—to support farmers and promote the adoption of improved varieties through the Kilo per Kilo program.

In 1982, the Bean/Cowpea Collaborative Research Support Program (CRSP) signed an agreement with Mexico's National Research Institute for Forestry, Agriculture and Livestock (INIFAP) to collaborate in developing improved bean varieties for the semiarid highlands of Mexico's North-Central region. During 1990-2000, INIFAP released several improved bean varieties that were distributed via the Kilo per Kilo program and adopted by farmers in the semiarid region.

The economic impact assessment of bean research is essential to provide decision-makers with information to improve the allocation of research resources.

The objectives of the study are to describe Mexico's bean subsector, analyze the factors associated with adoption of the improved bean varieties released by INIFAP in the 1990s, identify factors that contributed to explaining the participation of farmers in the government's seed distribution program (Kilo per Kilo), and estimate the net social gains generated by public investment in agricultural research and extension to develop and distribute improved bean varieties in northern Mexico.

The study area includes the states of Chihuahua, Durango, and Zacatecas, which account for 62% of the Mexico's rainfed bean production area. The results reported in this study include a rapid appraisal assessment of the bean subsector, an evaluation of government support policies affecting the bean subsector, a statistical and econometric analysis of improved bean seed adoption and farmer participation in the Kilo per Kilo program (based on survey data), and an estimation of the economic returns to public investment in bean research and extension (using the economic surplus method).

The adoption analysis indicates that the improved bean varieties Pinto Villa and Pinto Mestizo have been widely adopted in Chihuahua and Durango, that these varieties have yields that are 20.6% higher that traditional pinto bean varieties and that the yield difference is statistically significant. The economic analysis indicates that if a closed economy model is assumed, the financial and economic NPVs are positive and the IRRs are 17.5 and 21.4 %, respectively. If an open economy model is assumed, the financial and economic NPVs are positive and the IRRs are 21.3 and 20.7 %, respectively. The results from both models are consistent and suggest that public investment in bean research and extension is profitable (opportunity cost of capital=10%). Thus, the government should continue investing in bean research in northern Mexico.

DEDICATION

This dissertation is dedicated to:

My parents

Alvaro Gonzalez-Franco and Estela Ramirez-Echevarria

My grandmother

Flor de Maria Echevarria P. de Ramirez

My dear aunt

Maria del Consuelo Ramirez-Echevarria

Patricia and our three sons

Leon David, Horacio Alejandro, and Edgar Orlando.

My brother, sister, and friends.

ACKNOWLEDGEMENTS

I express my sincere gratitude to Dr. Richard Bernsten, my major professor for his attentive, supportive, and critically constructive comments and suggestions during the dissertation process. I also thank the other members of my guidance committee: Drs. Eric Crawford, Stephen Harsh, James Kelly, James Oehmke, John Staatz, and Irvin Widders, for their timely and valuable comments.

This research would have been virtually impossible without the logistic and financial support from the Instituto Nacional de Investigaciones Forestales, Agricolas y Pecuarias (INIFAP) and their directors—especially Dr. Jesus Moncada de la F., Dr. Ramon Martinez P., Dr. Sebastian Acosta N., Dr. Rodrigo Aveldaño S., Dr. Homero Salinas G., and M.C. Arnulfo Pajarito R.—and the Consejo Nacional de Ciencia y Tecnologia (CONACYT) en Mexico for awarding me a graduate training fellowship. In addition, I greatly appreciate the assistance and suggestions provided by my colleagues at INIFAP, especially Jorge Acosta G., Francisco J. Ibarra P., Evenor I. Cuellar R., Adan Castillo R., Mario Valdes G., Jesus Lopez H., Rigoberto Rosales S., Pablo Fernandez H., Hector Perez T., Efrain Acosta D., Benito Cazares E., and Roman Zandate H.

I also thank thee Bean/Cowpea Collaborative Research Support Program (B/C CRSP) for its financial support of my field work in Mexico (through USAID grant # DAN-G-SS-86-00008-00), the support of the Department of Agricultural Economics at Michigan State University (MSU) for providing funding for me to finish my doctor of philosophy program, and the support of the Comunidad Latina for my family.

Special thanks for support and friendship of students of the Department of Agricultural Economics at MSU. I am especially grateful to my study group during most part of the program: Yoko Kijima, Patricia Masego Makepe, Asfaw Negassa Muleta, and Edward Pepukayi Mazhangara. Also for the friendship and advise of David Mather, Youssouf Camara, Denise Mainville, and Juan Estrada-Valle.

In Durango, Mexico, special thanks to the staff of the Secretaria de Agricultura, Ganaderia, Desarrollo Rural, Pesca y Alimentacion (SAGARPA) of the Federal Government, the Secretaria de Agricultura, Ganaderia y Desarrollo Rural (SAGDR) of the Government of the State of Durango, and of the Instituto Nacional de Estadistica, Geografia e Informatica (INEGI), especially to Felipe Aviles L.

Most important, I haven't finished the dissertation without God's help.

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CHAPTER 1. INTRODUCTION

1.1 General Background

During the decade of the 1990s, the agricultural sector's share of Mexico GDP declined by 49 percent. In 1990, the agriculture, livestock, and forestry sector accounted for an average of 7.2% of total GDP (MX$ 738,898 million; approximately US$ 262,933 million). In contrast, in 2000 the sector[1] accounted for an average of only 3.7% of total GDP (MX$ 5,491,373 million; approximately US$ 575,615 million).

Several factors have had a significant impact on the agricultural sector, in general, and the bean subsector in particular, including rapid population growth and urbanization, slow growth in rural GDP, and market liberalization policies.

During the decade, Mexico's population increased by 19 percent. In 1990, Mexico's total population was 83.2 million, of which 60.3 million was urban and 22.9 million was rural. In contrast, in 2000 total population was 98.9 million, of which 73.6 million was urban population and 25.3 million was rural population. While the urban population increased rapidly (22%), the rural population remained relatively constant.

In addition, while Mexico's nominal GDP per capita increased from US$ 3,142 to US$ 5,758 (83%), GDP per capita in the agricultural sector averaged approximately one-fourth of the average for the whole economy, highlighting the importance of promoting agricultural development (INEGI 2002, FAO 2002a, IPED 2002).

During the 1990s Mexico implemented policies to liberalize its economy. Since joining the GATT in 1986 the Mexican government has promoted an open trade policy in order to expand trade with its most important trading partners. Trade liberalization has

[1] The most important economic activity was crop production (62.9% of sectoral GDP), followed by livestock (32.0%) and forestry (5.0%).

taken place gradually, primarily by replacing import licenses on many agricultural products with tariffs and by decreasing tariffs over time according to arranged schedules. In addition, most quantitative export restrictions for agricultural products have been eliminated. Finally, Mexico has significantly simplified its sanitary and phytosanitary regulations for importing agricultural products, fertilizers, and chemical agricultural inputs.

In 1994, when Mexico entered the North American Free Trade Agreement (NAFTA), it made a commitment to eliminate all the tariff and non-tariff barriers among Canada, Mexico, and the U.S. Gradually, import licenses are being replaced by a system of equivalent tariffs and quotas. While tariffs were eliminated immediately for some products, for others tariffs were scheduled to be phased-out in periods of five, ten, and fifteen years. Quotas, which are tariff-exempt, will increase gradually over time, generally at a rate of 3% per year, and will eventually be eliminated along with tariffs. Although all agricultural products were included in the NAFTA agreement, long phase-out periods were negotiated to protect import-sensitive agricultural products. Specifically, for both maize and beans, the most important agricultural products in Mexico, a phase-out period of fifteen years (1994-2008) was established to facilitate the process of transition. While NAFTA is Mexico's most important trade agreement, Mexico has also signed bilateral trade agreements with other countries that promote trade liberalization.

1.2 Problem Statement

After corn, common bean (*Phaseolus vulgaris L.*) is the second most important basic grain crop in Mexico, in terms of area planted. In addition, beans are the second most important component in the diet of the majority of the Mexican population.

During the 1990s, the harvested bean area averaged 1.9 million hectares, with an average yield of 632 kg/ha, and an average production of 1.2 million Mt. However, during the last one-half of the decade, the bean subsector experienced negative growth. During 1996-2000, the total harvested area decreased by 2.0% and average yield decreased 2.5%, compared to 1990-1995. As a result, production declined 4.5% in 1996-2000, compared to 1990-1995.

In the 1990s, the annual value of dry bean production (in real terms, base-year=1999) averaged MX$ 8,050 million, equivalent to approximately US$ 847 million. This value represented only 6.1% of the total value of agricultural production in Mexico. Considering that dry beans averaged 10.6% of total planted area during the same period, it is possible to conclude that beans are a relative low value crop. However, it is important to take into account that most of this crop is currently grown in very dry regions of the country where farmers have few cropping options that are more profitable than beans (Tellez 1994; FIRA 2001).

On June 1st 1982, the Bean/Cowpea-Collaborative Research Support Program[2] (CRSP) signed an agreement with Mexico's National Research Institute for Forestry, Agriculture and Livestock (INIFAP) to collaborate in developing improved bean varieties for the Mexico's semiarid highlands of the North-Central region. During the past ten

[2] The Bean/Cowpea Collaborative Research Support Program is a research and training program that supports international research partnerships to increase the availability of beans and cowpeas.

years (1990-1999), INIFAP has released several improved bean varieties that have been adopted by farmers in the semiarid region (*e.g.*, Pinto Villa and Pinto Mestizo).

However, to date the economic impact of these varieties has not been evaluated. Thus, a study to assess the level of farmer adoption of improved bean varieties and to estimate the financial and economic rate of return to investments in bean research in Mexico is required to determine the extent to which these research investments have benefited farmers and consumers and to provide information that will assist breeders in setting future bean research priorities. Thus, this study focused on assessing the economic impact (*i.e.*, costs, benefits, and returns) of improved bean varieties in northern Mexico, and on identifying the factors that have contributed to realizing the observed impact.

1.3 Justification of the Study

Numerous studied have demonstrated the critical role that increasing agricultural production plays in the process of economic development and the key contribution of research in promoting growth in agricultural production. However, now facing tighter budgets, research administrators are increasingly being asked to provide evidence than the costs of public-sector funded research are justified by the benefits (Alston *et al.* 1998, 1999).

The government of Mexico needs to justify its investments—as do other governments and donors—because the economic value of public investment may not be obvious. It is particularly difficult to observe the impact of bean research because the benefits are diffused over many years and millions of dispersed producers and consumers. Without an economic analysis, it is difficult to assess the social value of new technologies and to make informed judgments about the trade-offs in allocating scare scientific resources (Masters 1996).

Thus, the subject matter of this dissertation—measuring the economic impact of bean research targeted at developing improved bean varieties—is justified by the importance of dry beans in the agricultural Mexico's agricultural economy and the need to provide decision-makers with information that they require to improve the allocation of research resources (Norton and Davis 1981a). In addition, this study's contribution to the literature is to support or refute "conventional wisdom" that investments in agricultural research and development generate large dividends to society, more than enough to support continued funding in the future.

Furthermore, this study generates insights that meet the information needs of the main stakeholders of bean research investments: 1) Government decision-makers, who desire information on the payoff of agricultural research, since it competes with alternative uses for public funds; 2) Research administrators, who desire information on the expected payoffs from funds allocated to alternative research investments, and 3) The general public (consumers and producers included), who has become increasingly concerned about the productivity of their tax payments and government investments.

1.4 Research Objectives

The general objective of the study is to describe Mexico's bean subsector, analyze the factors associated with adoption of the improved bean varieties released by INIFAP in the 1990s, identify factors that contributed to explaining the participation of farmers in the government's seed distribution program "Kilo por Kilo" in northern Mexico, and estimate the net social gains of public investment in agricultural research to develop improved bean varieties.

The specific objectives of this study are to:

1) Describe the historical and current status of the Mexican bean subsector including trends in: a) bean supply (cropped area, production and yields, imports and exports), b) demand for beans (changes in consumer preferences, aggregate consumption, consumption per capita, and consumption by market class), c) bean prices (real and wholesale bean prices, price seasonality and international prices), and d) marketing (bean marketing, marketing channels and the domestic bean industry). The purpose of the subsector analysis is to identify the major constraints facing the Mexican bean subsector and demonstrate how research can contribute to relaxing some of these constraints.

2) Analyze the role that government programs—including "Alianza para el Campo", "PROCAMPO", and "Kilo por Kilo"—have played in supporting research, agricultural extension, technology adoption, and growth in bean production in Mexico. The purpose of the analysis is to identify the government policies that have constrained or facilitated bean research at INIFAP and farmer adoption of improved varieties, including the seed distribution program of the Secretariat of Agriculture.

3) Measure the rate of adoption of improved bean varieties grown under rainfed conditions in the semiarid highlands of northern of Mexico, including the states of Chihuahua, Durango, and Zacatecas. In addition to estimating the aggregate level adoption of improved varieties, data collected through a formal survey of bean farmers are analyzed to identify the factors explaining farmer adoption and program participation.

4) Carry out an *ex post* impact assessment of the investments in bean research and extension in Mexico, using the economic surplus method. The purpose of the *ex post* impact analysis is to estimate the rate of return of the investments made by the Bean/Cowpea CRSP and by the Mexican government through INIFAP to generate improved varieties and by SAGAR to promote the adoption of improved bean varieties under rainfed conditions in the states of Chihuahua, Durango, and Zacatecas.

5) Propose recommendations to guide future investments in bean research and extension that can help to accelerate the rate of technology development and diffusion of new improved bean varieties, and to increase productivity in Mexico's bean subsector.

1.5 Dissertation Organization

The dissertation is divided into seven chapters. Chapter 2 is divided into two sections. Section one presents a review of previous studies and concepts related to the bean subsector, technology adoption, and economic impact analysis. Section two describes the methods used to select the area of study, to carry out the rapid appraisal, and to implement the farmer's survey.

Chapter 3 describes the most important characteristics of Mexico's bean subsector and the most relevant constraints and opportunities that the bean subsector has faced during the past decade. The chapter is divided into five sections. Section one describes the characteristics of bean supply by analyzing the trends in total bean production, bean production by season and by water condition, production seasonality, and the evolution of bean imports and exports. Section two analyzes trends in the characteristics of bean demand by examining changes in preferences, apparent consumption, consumption per capita, and bean consumption by market class. Section three analyzes trends in bean prices, including the evolution of real prices to producers, wholesale price seasonality, international prices, and marketing margins. Section four describes the characteristics of the bean marketing system, marketing channels, and production and costs of the domestic bean industry. Section five summarizes the chapter.

Chapter 4 examines governmental policies and programs that have influenced bean research, seed distribution, and farmer adoption of improved varieties of beans in Mexico. The chapter is divided into four sections. Section one describes the government's support programs, price policy, trade agreements, farm credit, and crop insurance related to bean production and marketing. Section two describes the most important programs and organizations that promote bean research, technical assistance, and the multiplication of improved seed. Section three analyzes the role that the Kilo per Kilo program has played in the distribution of improved bean seed in the rainfed areas of northern Mexico in the states of Chihuahua, Durango, and Zacatecas. Section four summarizes the chapter.

Chapter 5 presents an estimation of the rate of adoption of improved bean varieties and examines the factors that contribute to explaining farmer adoption and their participation in the seed distribution program, based on the statistical analysis of data collected from the surveys of bean farmers. The chapter is divided into six sections. Sections one and two present data that characterize the surveyed farms and farmers in northern Mexico. Section three analyzes factors that are associated with farmer participation in government programs, farmers' storage practices, and prices they received for their bean crop. Section four reports the results of the analysis of area planted, yields, and characteristics of the improved bean varieties. Section five analyses the effect of the seed distribution program on farmers' adoption of improved bean varieties and reports the results of an econometric analysis of the factors explaining the participation of farmers in the program. Section six summarizes the chapter.

Chapter 6 estimates the returns to investment in agricultural research for the development of improved bean varieties in the rainfed areas of northern Mexico. The chapter is divided into seven sections. Section one describes the data used for the analysis. Section two explains the basic assumptions of the economic surplus method and the formulas used to estimate the returns to research investment in a closed economy. Sections three and four report the results for the financial and economic analysis. Section five uses sensitivity analysis to explore the effects that changes in key factors have on the rates of return estimated and on the distribution of the benefits between consumers and producers. Section six applies the small open economy model for the economic analysis. Section seven summarizes the chapter.

Finally Chapter 7 summarizes the most important findings of this dissertation and presents the most important conclusions and policy implications for government decision-makers, bean researchers, and extension services in Mexico. The chapter ends with a discussion of the limitations of the study and future research needs.

CHAPTER 2. LITERATURE REVIEW AND METHODS

This chapter is divided into two main sections. Section one reviews the literature related to the topics analyzed in this dissertation, including studies that have been carried out recently by several authors in different countries. This review identifies insights from previous studies, which guides the analysis reported in this study. Section two explains how the study area (Chihuahua, Durango, and Zacatecas) was selected and the methods that were used for collecting secondary and primary data, determining the sample size, selecting the sample of farmers, and designing the questionnaire.

2.1 Literature Review

2.1.1 Bean Subsector Overview

A subsector has been defined as "the vertical set of economic activities in the production and distribution of a closely related set of commodities" (Shaffer 1973), or alternatively as "an interdependent array of organizations, resources, laws and institutions involved in producing, processing and distributing an agricultural commodity" (Marion *et al.* 1986). The concept of subsector studies and the methodology was further developed and utilized by several authors in the 1990s as a tool for analyzing microenterpise programs (Haggblade and Gamser 1991), agribusiness subsector assessments (Miles 1994), and agricultural research program planning (Boughton *et al.* 1995).

According to Staatz (1997), the subsector approach examines how production and distribution activities for a commodity are organized within the economy and asks how the productivity of those activities can be increased, either through improved technologies or better institutions and policies, to better coordinate various stages of production and distribution. The studies mentioned above provided the theoretical framework to carry out the bean subsector overview presented in this dissertation.

In recent years, bean subsector studies have been conducted in Honduras and Guatemala. The Honduran bean subsector study focused on the subsector's historical development, current status, and policy issues—including trends in production, adoption of improved varieties, and implications for policy makers, researchers and extension (Martel-Lagos and Bernsten 1994; Martel-Lagos 1995). Similarly, the Guatemalan study presented an overview of the domestic bean subsector, focusing on constraints and opportunities for vertical coordination and expansion of the bean processing industry (Estrada-Valle 2001).

In the case of Mexico, recent studies from research centers (Rinderman *et al.* 1998), government agencies (Tellez 1994), and universities (Calva 1992, 1997) have analyzed the evolution of the agricultural sector and its interaction with the rest of the economy. Specific studies, carried out mainly by the Secretariat of Agriculture in Mexico (SAGAR 1998, 2000), closely related branches (ASERCA 1997, 1998), and financial organizations (FIRA 1994, 2001) focused on various aspects of the bean subsector in Mexico. These empirical studies provided important background information that is used incorporated in this study's overview of the Mexican bean subsector.

A formal subsector analysis requires a considerable amount of time and financial resources. Given limited resources, this bean subsector overview utilized rapid appraisal or reconnaissance techniques to obtain the most relevant information needed to understand the key aspects of the bean subsector in Mexico. As stated by Holtzman (1986) and Chambers (1981), a rapid appraisal can be used to generate a broad and preliminary overview of the organization, operation and performance of a food system or its components, which is designed to identify system constraints and opportunities. In addition, it can be used to identify system dynamics, linkages and overall problems, which can then be examined more intensely during follow-up programs of research. The rapid appraisal techniques used for this dissertation included informal interviews with key informants, a review of literature, and the collection of information and secondary data. Insights gained from the rapid appraisal guided the design of the survey of bean farmers in Chihuahua, Durango, and Zacatecas.

2.1.2 Technology Adoption Studies

The adoption process was defined by Rogers (1962) as "the mental process an individual passes from first hearing about an innovation to final adoption". However, a distinction should be made between individual (farm-level) adoption and aggregate adoption. Final adoption at the level of the individual farmer is defined as the degree of use of a new technology in the long-run equilibrium, when the farmer has full information about the new technology and its potential. In the context of aggregate adoption behavior, the diffusion process has been defined as "the process of spread of a new technology within a region". Aggregate adoption is measured by the aggregate level of use of a specific technology within a given geographical area or a given population (Feder *et al.* 1985).

There is a great diversity of studies on adoption of technology. Some focus more on models of the adoption behavior of individual farms, while others focus more on the models of aggregate adoption. Most of the theoretical studies of the adoption behavior of individual farmers use static analysis that relates the degree of adoption to factors affecting it. Most of the aggregate adoption models are dynamic and derive analytically the behavior of the diffusion process over time (Feder *et al.* 1985). The adoption of technology has been extensively analyzed in the survey on adoption of agricultural innovations in developing countries (Feder *et al.* 1985) and in the study on technology adoption decisions in small farms (Rauniyar and Goode 1992). These studies indicate that constraints to the rapid adoption of innovations include factors such as the lack of credit, limited access to information, aversion to risk, inadequate farm size, inadequate incentives associated with farm tenure arrangements, insufficient human capital, absence of equipment to relieve labor shortages, problems of supply of complementary inputs, and inappropriate transportation infrastructure.

The econometric approach for analyzing technology adoption was used by Griliches (1957, 1980) and Dixon (1980) for exploring the economics of technological change in the case of hybrid corn in the U.S. by using logistic growth functions. Logistic curves also were used by Jarvis (1981) to predict the diffusion of new technologies in Uruguay. A review of some possible empirical models for studying technology adoption was done by Besley and Case (1993). One of the most recent adoption studies using an econometric approach (Kosarek *et al.* 2001) analyzes the factors explaining the diffusion of hybrid maize in Latin America and the Caribbean region (LAC), using cross-sectional data from 18 countries and a two-limit Tobit model. They conclude that if policy makers in LAC are to accelerate the diffusion of hybrid maize, they will have to ensure an environment in which it is not only profitable for producers to adopt improved varieties, but also profitable for the seed industry to produce and sell high-quality seed.

In the case of Mexico, some of the most important characteristics of the technology transfer process that affected small farmers were analyzed by Gonzalez (1988). Other studies have focused on analyzing the farm level and aggregate adoption of new technologies developed by the INIFAP for the semiarid highlands of Mexico (Gonzalez 1992, 1996) and evaluating the transfer of technology for dry beans (Pajarito and Moncayo 2000). Also an econometric approach using logistic curves was used by Byerlee and Hesse de Polanco (1986) to study the adoption of improved technological components in Mexico. They suggested that agricultural research and extension programs in developing countries, rather than following the conventional package approach, should be designed to take into account the fact that farmers adopt improved technological components in a stepwise manner.

In this dissertation, the adoption of technology was analyzed at the individual farmer and aggregate levels by using the methodology suggested by CIMMYT (1993) for survey design and by using the theoretical framework provided by the studies on adoption of technology mentioned above, especially Feder *et al.* (1985). For the econometric analysis the limited dependent variable probit model is used to investigate the farmers' participation in the seed distribution program following standard econometric procedures (Amemiya 1981, Kennedy 1992, Gujarati 1995, Greene 1997, and Wooldrige 2000).

2.1.3 Economic Impact Analysis

The main purpose of an impact assessment analysis of agricultural research is to value and compare the costs and benefits that arise from a situation "without" research, against an alternative situation "with" research. The difference is the incremental net benefit arising from investing in research (Masters 1996, Gittinger 1982). It is particularly difficult to observe the impact of agricultural research because the benefits are diffused over many years and many dispersed producers and consumers. Economic studies are needed to estimate the economic value of scientific knowledge or new technologies—including the distribution of benefits and costs—and to make informed judgments about the trade-offs in allocating scarce resources (Alston *et al.* 1998). A review of a wide range of methods for evaluating agricultural research can be found in Schuh and Tollini (1979). Also a comprehensive review of the major research techniques that have been developed to evaluate returns to agricultural research was done by Norton and Davis (1981b).

Methods for doing an impact assessment are generally divided into three main groups: a) econometric methods, aimed at estimating the marginal productivity of research over a long time period and a variety of research activities; b) programming methods, aimed at identifying one or more optimal technologies or research activities from a set of options; and c) economic surplus methods, aimed at measuring the aggregate social benefits of a particular research project. For each method, the most common approaches used for the analysis can be divided into two categories: *ex ante* and *ex post* studies. The former category is applied for technologies that have not yet been adopted, while the latter is applied for technologies already being used by farmers (Masters 1996).

Given that the purpose of this study is to measure the aggregate social benefits derived from farmer adoption of improved bean varieties, the method of economic surplus was selected. The economic surplus method is the most common approach for analyzing the welfare effects of agricultural research in a partial-equilibrium framework, and it can be applied to the broadest range of situations. The impact assessment of the investment in research and extension of bean improved varieties (IVs) reported in this dissertation falls under the category of *ex post* impact studies because the varieties are already being used by the farmers.

Under the theoretical framework of partial equilibrium analysis, the focus is on a single agricultural market. Farmer adoption of new technologies is expected to shift the supply curve to the right, which will lead to a higher quantity of output and lower price; and to changes in the consumer surplus, the producer surplus, and the social surplus (Oehmke 2000). Implementation of the economic surplus analysis to evaluate agricultural research can be broken dawn in five components (Alston *et al.* 1998): 1. Defining the problem, 2. Compiling the data, 3. Measuring the research-induced supply shift or K-factor, 4. Analyzing the data, and 5. Interpreting and using the results. These procedures were used to guide the economic analysis in this dissertation.

Examples of *ex post* impact assessment studies of investments in research and extension for different crops include Sterns' (1993) *ex post* assessment of investments in Cameroon's cowpea and sorghum research-extension systems from 1979 to 1987, Dimithe's (1994) *ex post* estimation of the rate of return on maize research and extension in Northern Cameroon from 1979 to 2000, Howard's (1994) economic impact study of improved maize varieties in Zambia from 1978 to 1991, and Mather's (2001) economic assessment of bean research in the Dominican Republic. The last two of these studies used an explicit economic surplus method for impact assessment.

2.2 Methods of Analysis

2.2.1 The Area of Study

The purpose of this dissertation is to assess the economic impact of improved bean varieties released by INIFAP in the early and mid 1990s: Pinto Villa 1990, Flor de Mayo M38 1994, Pinto Mestizo 1996, Pinto Bayacora 1996, Negro Altiplano 1996, and Negro Sahuatoba 1996 (Table 2.1). These varieties were developed for the rainfed conditions of Mexico's semiarid highlands with low rainfall (less than 450 mm a year), soils with low level of fertility, and agronomic problems associated with monocropping beans. In the states of Chihuahua, Durango, and Zacatecas—the three most important states where beans are grown under rainfed conditions—beans are grown during the Spring-Summer season (from July to October). The analysis for Chihuahua and Zacatecas was done using secondary data and a drop-off survey, while the analysis for Durango was done using secondary data and a face-to-face survey with farmers.

From 1990 to 2000, the total area planted to dry beans in Mexico averaged 2.2 million hectares. Approximately 85% of the total planted area was grown under rainfed conditions (SAGAR 2000). The states of Chihuahua, Durango, and Zacatecas (Figure 2.1), accounted for about 62% (1.15 million ha) of the total rainfed bean area. Each state's share of the total was as follows: Chihuahua 10% (0.19 M ha), Durango 15% (0.28 M ha), and Zacatecas 37% (0.68 M ha). Considering that beans are grown in all 32 states of Mexico, it is evident the importance of the states that were selected for the study.

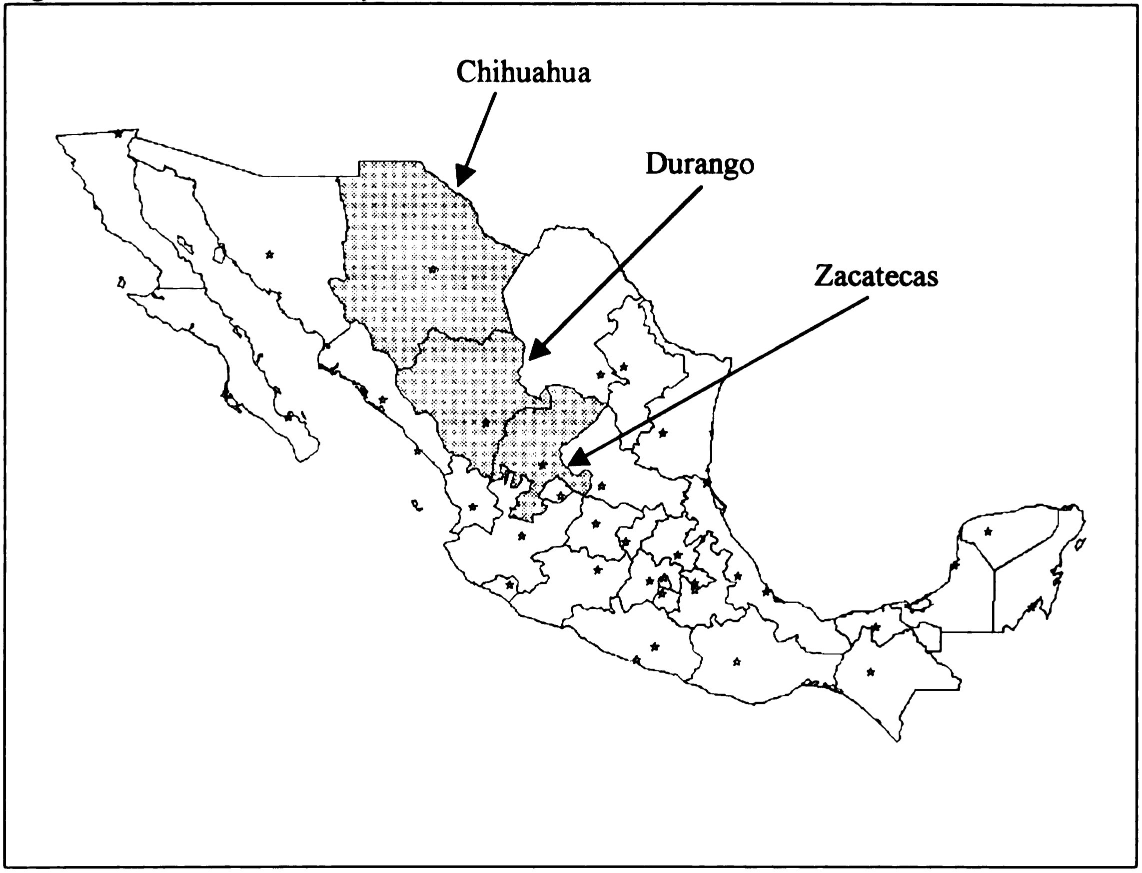
In Durango beans are grown in most of the state's 39 counties. The area of study was defined first by considering the most important counties growing beans, based on the number of hectares planted to beans under rainfed conditions.

Table 2.1 Characteristics of the Improved Bean Varieties Developed by INIFAP for the Rainfed Conditions of Northern Mexico.

Variety[a]	Recommended latest planting date	Seed color	Seed shine	Seed size	Plant type[b]	Days to flowering	Days to maturity	Yield (kg/ha)
Pinto Villa	Jul 20	Brown pinto pattern	Semi-shiny	Medium	Semi-prostrate	43	85	500-900
Flor de Mayo M38	Jul 15	Pink color pattern	Semi-shiny	Medium	Semi-erect	45	90	400-700
Pinto Mestizo	Jul 25	Brown pinto pattern	Shiny	Large	Semi-erect	40-45	80	400-700
Pinto Bayacora	Jul 25	Brown pinto pattern	Shiny	Large	Erect	35	80	300-700
Negro Altiplano	Jul 15	Black	Opaque	Small	Erect	40-45	96	400-900
Negro Sahuatoba	Jul 15	Black	Opaque	Small	Erect	40-45	98	400-900

a. Only the characteristics of the varieties for the semiarid highlands included in the study are described.
b. All these varieties have a short vine.
Source: INIFAP (2000a, 2001).

Figure 2.1 The Area of Study in Northern Mexico.



Most of area and production are concentrated in a small number of counties located in the region known as "Los Llanos" of Durango. In this region four counties (Cuencame, Guadalupe Victoria, Panuco de Coronado, and Peñon Blanco) account for about 47% of the state's total rainfed area planted to beans. The participation of each county in the total is as follows: Cuencame 16%, Guadalupe Victoria 18%, Panuco de Coronado 7%, and Peñon Blanco 6% (INEGI 2000).

The second step was to consider those counties in which the seed of improved variety was distributed through the government's Kilo per Kilo program. Information obtained from the Secretariat of Agriculture in Durango for year 2000 indicated that improved seed was distributed in the District of Rural Development 03 "Guadalupe

Victoria"—which is located in "Los Llanos de Durango" region. Of the total amount of seed, the following percentages were distributed: Cuencame 19.4%, Guadalupe Victoria 19.0%, Panuco de Coronado 27.6%, Peñon Blanco 28.7%, Santa Clara 3.8%, and other counties 1.5% (SAGAR-Durango 2000).

Based on the previous information, four counties (Cuencame, Guadalupe Victoria, Panuco de Coronado, and Peñon Blanco)—which accounted for 94.8% of the seed distributed—were selected for the survey in Durango. Within these counties, the quota of respondents was allocated across villages roughly in proportion to their respective area planted to beans and in which the Kilo per Kilo program distributed the improved seed to farmers. In each village, farmers were randomly sampled from a list of individuals who were growing beans under rainfed conditions during the Spring-Summer season 2001. For the drop-off survey in Chihuahua and Zacatecas, the counties and villages were selected in the same way as in Durango, and individuals were selected randomly. The counties included for the survey in Chihuahua were: Namiquipa, Cuauhtemoc, and Guerrero. The counties included for the survey in Zacatecas were: Sombrerete, Fresnillo, and Rio Grande.

2.2.2 Rapid Appraisal

A rapid appraisal or rapid reconnaissance is a flexible data collection procedure designed to learn about the most important characteristics, opportunities and constraints of the food system or a subsector in a cost-effective way. Several techniques can be used when doing a rapid appraisal. The rapid appraisal techniques used for this dissertation were collection of secondary data and informal interviews with key informants. The rapid appraisal for collecting the data required for the bean subsector overview, government policies, adoption of technology and economic impact analyses was carried out from September to December 2001.

Secondary data were collected at the country level and for the states of Chihuahua, Durango, and Zacatecas mainly from archives, reports, and publications from several government offices. The most important government agencies visited were the Secretariat of Agriculture, Livestock and Rural Development (SAGAR), the National Research Institute for Agriculture, Forestry and Livestock (INIFAP), the National Institute of Statistics, Geography, and Information (INEGI), the Trusts Instituted for Agriculture (FIRA), and Supports and Services for Agricultural Marketing (ASERCA).

The informal interviews with key informants carried out in the state of Durango focused on eliciting relevant information regarding development of improved bean varieties, seed distribution, and use of new varieties. The key informants were selected persons having special knowledge and understanding of bean research, support programs, and adoption of technology. Accordingly, the interviews were conducted with decision-makers, government staff, research administrators, bean researchers, and technicians.

2.2.3 Farmers' Survey

<u>Sampling Method</u>

For the face-to-face survey in Durango, the target population was the set of farmers growing beans under rainfed conditions during the Spring-Summer season 2001 (July to October) in previously selected villages in the counties of Cuencame, Guadalupe Victoria, Panuco de Coronado, and Peñon Blanco of the state of Durango. The villages selected were those villages having the largest area planted to beans and in which the improved bean seed was distributed through the government's Kilo per Kilo program.

Once the target population was identified, the next step was to find the appropriate list to be used as the sampling frame. In most lists, certain members of the target population are omitted, included more than once, or the list includes people that are not of interest for the study. The aim was to choose a list with a minimum of omissions, duplicate entries, and inaccuracies. After consulting with key informants, it was determined that the register of farmers maintained by PROCAMPO (a cash transfer program) is a reliable list that includes approximately 95% of all farmers in each county. Therefore, it was chosen as the sampling frame for drawing the sample.

The sample size was determined by using the usual statistical procedures. The sample size required depends basically on the desired level of confidence (Z), the maximum error of estimate (E), and how varied the population is with respect to the characteristics of interest. In this case, the main characteristic of interest is the proportion of farmers who have adopted an improved variety. To estimate a proportion (p) for a population the sample size is given by $n=(Z^2*pq)/E^2$; where $q=1-p$ is the proportion of the population not having the characteristic of interest (Hogg and Tanis, 1997).

In the case of Durango, to obtain an estimate with 95 percent level of confidence (Z=1.96, for two tails), assuming an equal number of adopters and non-adopters (proportion p=q=0.5), and ten percent sampling error (E=0.10), the sample size needed to estimate the proportion of farmers who have adopted improved bean varieties is:

n=(Z^2pq)/E^2=(1.96^2*0.5^2)/0.10^2=(3.84*0.25/0.01)=96 farmers

An initial sample size of 120 farmers (25% more than required) was considered appropriate in order to ensure a final sample size of 96 farmers after removing ineligible respondents, nonrespondents, and discarding incomplete questionnaires.

The sample was distributed among the four counties of interest in proportion to the area planted to beans in each county (Table 2.2). The number of farmers allocated in this way was considered to be the minimum number to be interviewed. However, with the help of enumerators, it was possible to carry out additional interviews. These additional farmers were selected randomly. Therefore, the actual number of interviews obtained was higher than the number initially computed. As a result, it was possible to reduce the sampling error from ten to seven percent.

Table 2.2 Number of Face-to-Face Interviews in Durango, Mexico 2001.

County	Planted area (ha)	Percentage of total	Quota minimum	Percentage of total	Actual Number	Percentage of total
Cuencame	51,908	34.8%	42	35.0%	69	32.8%
Guadalupe Victoria	57,316	38.5%	46	38.3%	73	34.8%
Panuco de Coronado	22,642	15.2%	18	15.0%	38	18.1%
Peñon Blanco	17,124	11.5%	14	11.7%	30	14.3%
Total	148,990	100.0%	120	100.0%	210	100.0%

Source: INEGI (2000).

Random sampling was used to select the farmers to be interviewed. The records of PROCAMPO farmers were obtained from the Secretariat of Agriculture. To draw the farmers for the list, first the lists of farmers in the villages of interest in each county were combined. Then farmers were selected randomly until the quota required for each county was filled. After filling the quota required per county and by adding the number of farmers selected for each county, a total number of 120 farmers was obtained. However, with the help of enumerators the number of interviews was increased to 210 (Table 2.2).

Questionnaire Design

The questionnaire for conducting the face-to-face survey with bean farmers in Durango was designed to obtain the information required to carry out an assessment of improved varieties adoption and economic impact analysis. The questionnaire included both open-ended and close-ended questions, depending on which format was considered better suited for providing the kind of information desired (Appendix A).

In order to detect potential problems in the wording of specific questions, the questionnaire was pretested twice with the assistance of researchers, surveyors, and farmers. Based on insights gained during the pretest, the questionnaire was revised by the researchers and these changes were discussed with the enumerators. Then, the enumerators used the revised questionnaire to interview an additional group of farmers. In both cases, the answers were analyzed with the team of enumerators. After revising individual questions, the final version of the questionnaire was obtained. For the drop-off surveys in Chihuahua and Zacatecas, the questionnaire was simplified and redesigned to make it easy for the respondents to complete the questionnaires on their own.

In addition to the basic information to identify the farmer and his/her location, questions were included to obtain information about the farmers' land inventory, crops planted, access to technical information, input use, bean varieties planted, grain yields, production costs per hectare, and access to credit. The questionnaire also included questions related to the farmers' ownership of farming machinery, sales of beans, assessment of improved bean varieties compared to traditional varieties, and participation in government programs. Finally, the questionnaire included questions related to the farmers' socioeconomic background, output storage, and transportation costs.

To carry out the survey, seven agricultural technicians living in the area of interest were hired as enumerators. These enumerators were selected, based on the recommendations of the Secretariat of Agriculture working in the counties covered by the survey. In September 2001, the enumerators were trained on how to conduct the field interviews and the criteria for selecting the respondents. The survey was implemented during the Spring-Summer season, during October and November 2001.

CHAPTER 3. AN OVERVIEW OF THE MEXICAN BEAN SUBSECTOR

In Mexico, common beans are an important crop, both in terms of consumption and production. Along with maize, common beans[3] are a fundamental component of the diet of the low-income population in both urban zones and rural areas. In addition, bean farmers utilize a high percentage of their production for self-consumption—from 18% to 30%, as reported in different studies. In terms of planted area, beans are second in importance (after maize), averaging 2.2 million hectares during 1990-2000, compared to approximately 8.5 million hectares for maize. Furthermore approximately 570,000 farmers grow dry beans—making it the second most important cropping activity (after maize) from the social point of view (FIRA 2001).

3.1 Characteristics of Supply

While dry beans are grown throughout the world, during 1998-2000 the Americas accounted for approximately 33.8% of the total bean area and 29% of total world production. During the 1990s the most important bean-producing countries in the Americas were Brazil (2,283,753 Mt, 38.0%), U.S. (1,289,186 Mt, 21.4%), and Mexico (1,067,712 Mt, 17.8%). In terms of area, the most important countries were Brazil (3,343,370 ha, 45.8%), U.S. (668,991 ha, 9.2%), and Mexico (1,783,629 ha, 24.4%). Thus, Mexico is the third largest producer of dry beans in the Americas and has the second largest planted area (FAO 2002a).

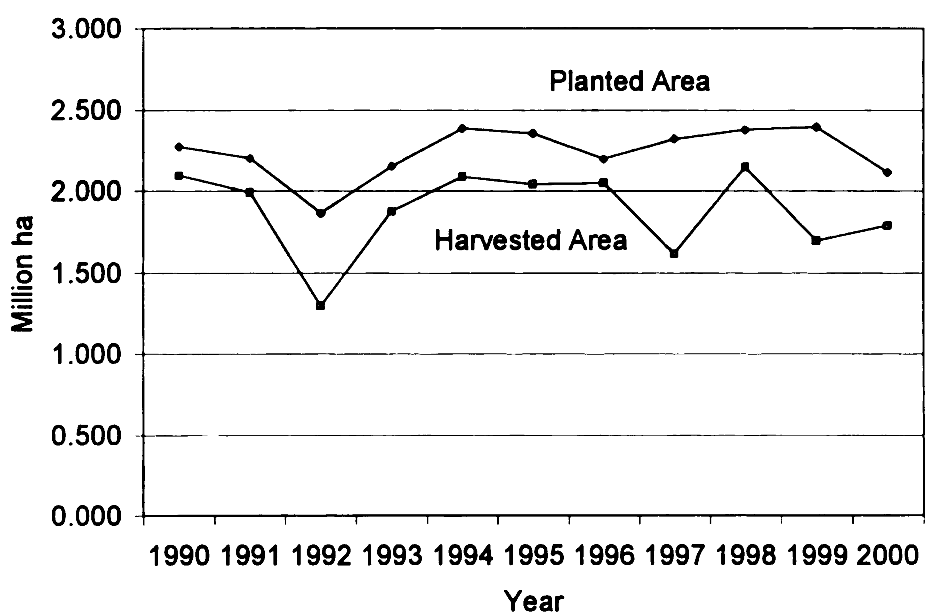
[3] In Mexico the common bean (*Phaseolus vulgaris L.*) is the most important bean included in the category "dry beans".

3.1.1 Area, Production, and Yields

Area Trends

During the period 1995-2000, Mexico's bean planted area averaged 2.2 million hectares (with a standard deviation of 0.2 million ha and a coefficient of variation of 7%). While the total planted area increased 3.4% during 1996-2000, compared to 1990-1995, the harvested area decreased 2.0%, averaging 1.9 million hectares (with a standard deviation of 0.3 million ha and a coefficient of variation of 14%). While both the planted and harvested area have varied considerably from year-to-year (Figure 3.1), the harvested area has been more variable, due to erratic weather conditions and because approximately 85% percent of the total area is planted under rainfed conditions.

Figure 3.1 Total Planted and Harvested Area for Beans in Mexico, 1990-2000.



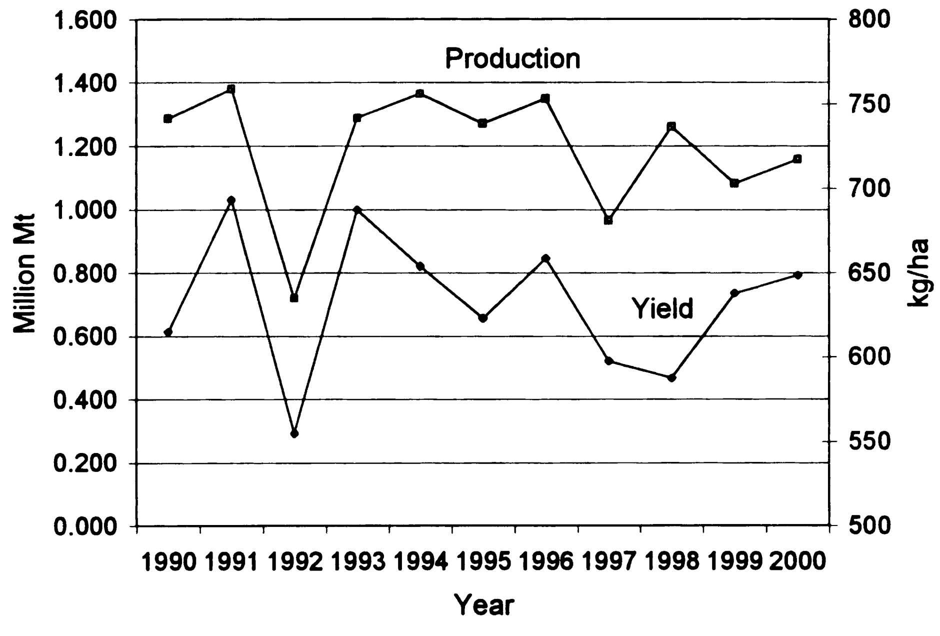
Source: Appendix B.

Most likely, the area planted to beans will decline in the future, given that producer prices have been declining. Thus, it is expected that the area planted to commercial beans will decline, while the area of beans grown for subsistence will remain roughly constant (FIRA 2001).

Average Yield Trends

Average bean yield has fluctuated over the 1990-2000 period, with slumps in 1992 and 1998, and peaks in 1991, 1993 and 1996 (Figure 3.2). During the decade, yield averaged 632 kg/ha with a standard deviation of 42 kg and a coefficient of variation of 7%. However, average yield decreased 2.5% in 1996-2000 compared to 1990-1995.

Figure 3.2 Total Bean Production and Average Yield in Mexico, 1990-2000.



Source: Appendix B.

Total Production Trends

Total production has fluctuated over the 1990-2000 period, and has followed a pattern very similar to the pattern of yields, with slumps in 1992 and 1997, and peaks in 1991, 1994 and 1996 (Figure 3.2). During the decade, production averaged 1.2 million Mt with a standard deviation of 0.2 million Mt and a coefficient of variation of 17%. The greater variability in production (compared to harvested area) is due the fluctuations in both yields and harvested area. Production declined 4.5% in 1996-2000 compared to 1990-1995.

3.1.2 Area, Production, and Yields by Season

In Mexico, beans are grown during two seasons: the spring-summer (SS) season and the fall-winter (FW) season. Most of Mexico's bean crop is grown during the SS season. During 1990-2000, the area harvested in the SS season averaged 1.6 million ha (84% of total harvested area), production averaged 0.9 million Mt (73% of total annual production), and yield averaged 546 kg/ha (Table 3.1). Yields are relatively low during the SS season because beans are grown mainly under rainfed conditions in the semiarid highlands where rainfall rarely exceeds 450 mm during the growing season. Farmers who grow beans during this season face considerably risk—given the great variability in weather due to both low levels of rainfall and the uneven distribution of rainfall over the growth period. Another weather-related problem is early frosts, which makes production very risky for farmers who are late in planting their SS bean crop.

Only a small share of Mexico's beans is produced during the FW season. During 1990-2000, the area harvested averaged 0.3 million ha (16% of total harvested area), production averaged 0.3 million Mt (27% of total annual production) and yields averaged

1,056 kg/ha (Table 3.1). Yields are relatively high during the FW season because most beans are grown under irrigated conditions. Irrigation reduces production risks and soils are more fertile in the irrigated area (*e.g.*, Valle del Fuerte, plateau of Sinaloa), which is mainly oriented to the production of cash crops like vegetables. The fact that yields are higher during the FW season than during the SS season explains why the FW season accounts for only 16% of harvested area, but 27% of total annual production. However, although yields are almost twice as high during the FW season as during the SS season, overall national average yield is low because most beans are grown during the SS season.

Table 3.1 Area, Yield and Production of Beans by Season in Mexico, 1990-2000.

Year	Spring-Summer			Fall-Winter		
	Harvested Area Million ha	Yield Kg/ha	Production Million Mt	Harvested Area Million ha	Yield Kg/ha	Production Million Mt
1990	1.888	573	1.081	0.206	1,000	0.206
1991	1.653	627	1.037	0.336	1,017	0.342
1992	1.080	476	0.514	0.215	949	0.204
1993	1.600	591	0.945	0.274	1,252	0.342
1994	1.775	571	1.012	0.312	1,127	0.352
1995	1.706	532	0.908	0.334	1,086	0.363
1996	1.768	601	1.063	0.280	1,021	0.286
1997	1.315	482	0.633	0.301	1,103	0.332
1998	1.789	517	0.925	0.357	941	0.336
1999	1.285	494	0.636	0.409	1,087	0.445
2000	1.579	537	0.848	0.301	1,034	0.311
Average	1.585	546	0.873	0.302	1,056	0.320

Source: SAGAR (2000).

Comparing trends in the early versus the late part of the decade of the 1990s indicates that average yields have declined over time, both in the SS and the FW season. However, harvested area and production have decreased for the SS season but increased for the FW season. When comparing the average in 1996-2000 with the average in 1990-

1995, during the SS season harvested area, yields, and production decreased by 6.2%, 6.4%, and 11.1%, respectively. In contrast, the same kind of comparison shows that during the FW season yields decreased 3.2%, while both area and production increased by 17.8% and 13.3%, respectively. This indicates that bean production is shifting from the SS season, mainly under rainfed conditions, to the FW season, where most beans are grown under irrigated conditions and that the increase in production is due to area expansion, which has offset decreasing yields and led to a positive increase in production.

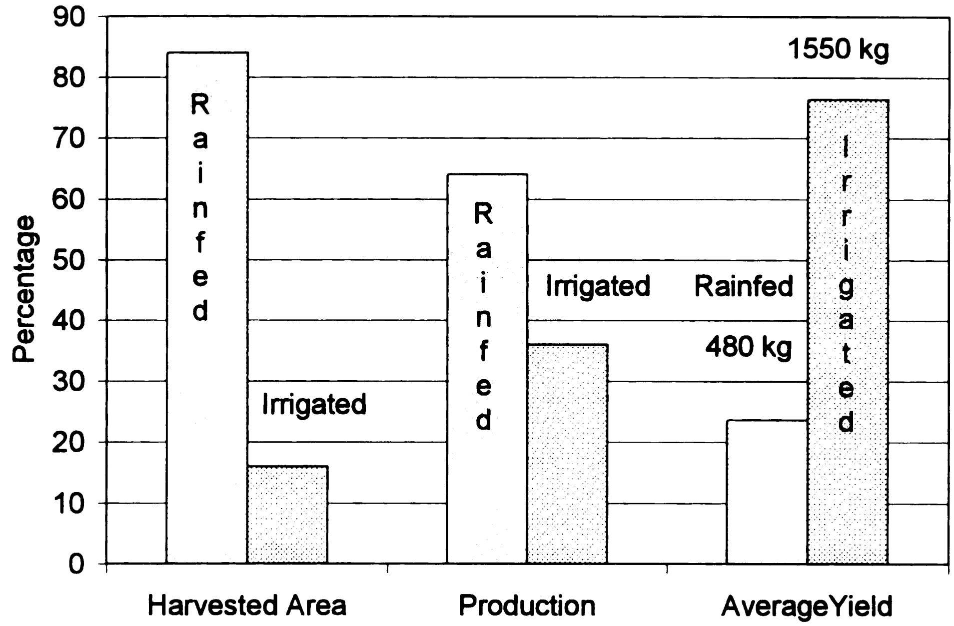
3.1.3 Production by Water Condition

In order to better understand trends in bean production, it is necessary to make a distinction between beans grown under rainfed versus irrigated conditions. During 1990-2000, an average of 1.6 million ha of the harvested area (84% of total harvested area) was rainfed and 0.3 million ha (16% of total) was irrigated (Figure 3.3).

Approximately 768,000 Mt of beans (64% of total annual production) were produced under rainfed conditions, while 432,000 Mt (36% of total) were produced under rainfed conditions. Yields averaged 480 and 1,450 kg/ha under rainfed and irrigated conditions, respectively.

It is also important to consider production by season and by water condition. During 1990-2000 in the SS season, approximately 83% of the harvested area was rainfed and 17% was irrigated. Yields averaged 456 and 1,456 kg/ha respectively, and about 77% of Mexico's SS season bean crop was produced under rainfed conditions while the other 23% was produced under irrigated conditions.

Figure 3.3 Harvested Area, production, and Yield under Rainfed and Irrigated Conditions in Mexico, 1990-2000.



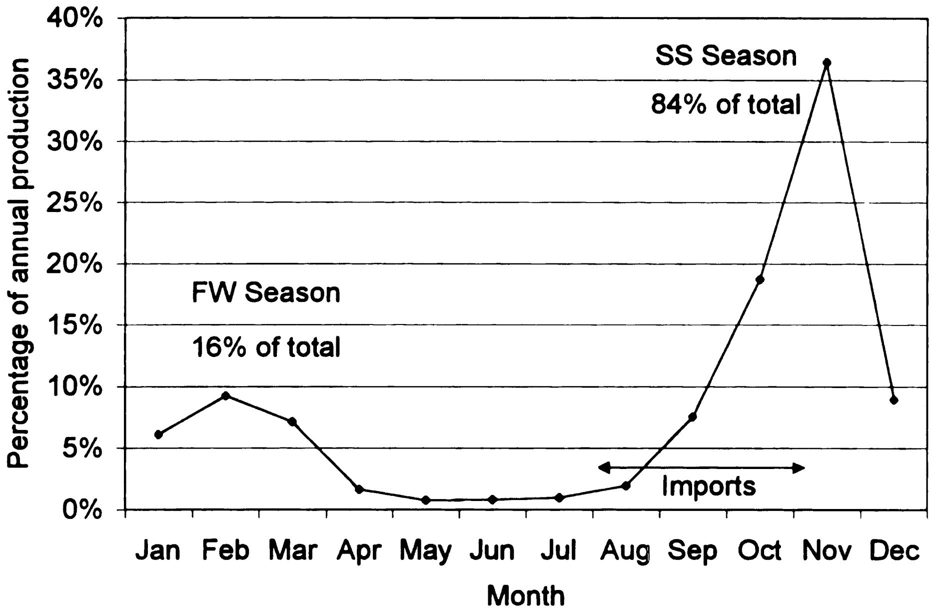
Source: SAGAR (2000).

In the FW season, approximately 48% of harvested area irrigated and 52% rainfed. Yields averaged 1,477 and 690 kg/ha, respectively, and about 67% of Mexico's FW season bean crop was produced under irrigated conditions while the other 33% was produced under rainfed conditions (SAGAR 2000).

3.1.4 Impact of Production Seasonality on Bean Marketing

Beans planted during the SS season are harvested during September to December and beans planted during the FW season are harvested during January to April. Because 84% of annual production is produced during the SS season, beans flood domestic markets during September-December (Figure 3.4). The abundant amount of beans in the domestic market during this period has contributed to lower price of domestic beans and making it more difficult for farmers to market their production. In contrast, there is a relative scarcity of domestic beans in the market during May to August.

Figure 3.4 Seasonality of Bean Production through the Months of the Year in Mexico, 1990-2000.



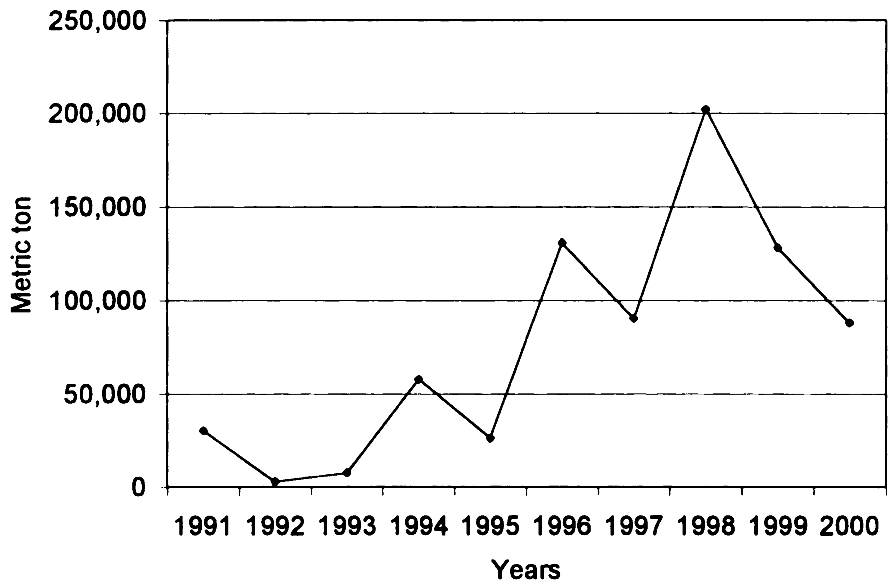
Source: SAGAR (2000).

During the past few years, Mexico has mainly imported beans during the months from August to October. Thus, there has been some overlap between the timing of imports and when domestic production reaches the market.

3.1.5 Bean Imports and Exports

Since Mexico does not produce enough beans to meet its domestic requirements, it has been importing beans of different market classes to meet part of the domestic demand (estimated at 1.2 million Mt during 1990-2000). As a result, in the 1990s, Mexico became one of the largest importers of beans in the world. During 1991-2000, Mexico imported an average of 76,277 Mt of dry beans per year (6% of total production), ranging from a minimum of 2,909 Mt in 1992 to a maximum of 202,005 Mt in 1998 (Figure 3.5). Although there have been a lot of fluctuation in the amount of beans imported during this period, a clear increasing trend over time can be observed.

Figure 3.5 Total Imports of Dry Beans into Mexico, 1991-2000.

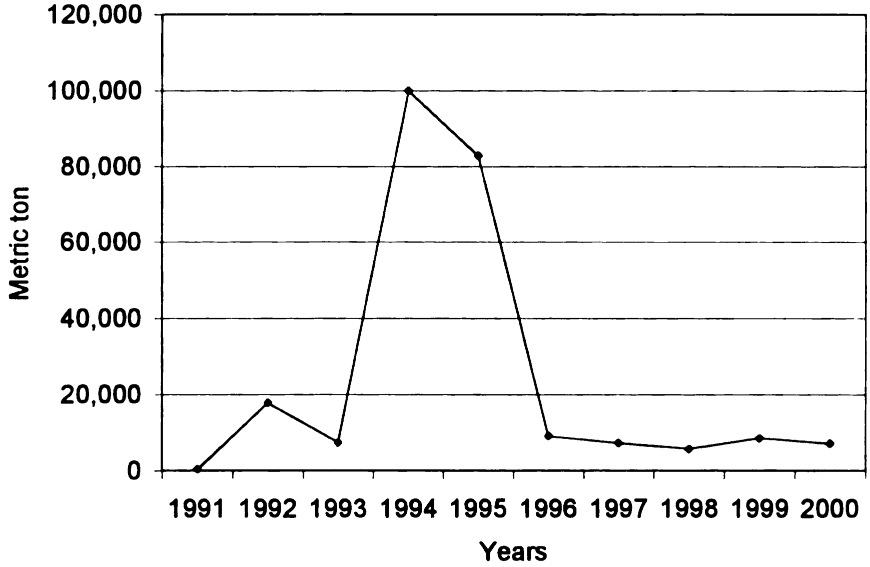


Source: FAO (2002a).

Regarding market class, most imports are pinto and black beans. The main source of imports has been the U.S. (95%), followed by Canada and Argentina (5%). Pinto beans is the most important market class in the U.S. During 1990-2000, pinto beans averaged 40% of total U.S. bean production, while black beans averaged 6% of U.S. production (CORECA 1999, ERS 2002a).

During the 1990s, Mexico exported only limited quantities of beans because almost all domestic production was used to meet domestic consumption requirements (Figure 3.6). During the 1991-2000 period, beans exported averaged only 24,568 Mt per year (2% of total production), ranging from a minimum of 420 Mt in 1991 to a maximum of 99,870 Mt in 1994 (mostly to Guatemala and Belize) (CORECA 1999). As exports have fluctuated from 1991 to 2000, there is no well-defined increasing or decreasing trend over time. In general exports have remained at very low levels, except in 1994 and 1995, when production exceeded domestic requirements.

Figure 3.6 Total Exports of Dry Beans from Mexico, 1991-2000.



Source: FAO (2002a).

Given the trends in imports and exports during the 1990s, Mexico has been a net importer of beans. During the 1991-2000 period, exports averaged only 24,568 Mt per year while imports averaged 76,277 Mt (Table 3.2). Thus, net imports—computed as imports minus exports—averaged 51,709 Mt per year (4% of total production), ranging from a minimum of -56,810 Mt in 1995 to a maximum of 196,317 Mt in 1998. This situation has resulted in a loss of foreign exchange and highlights the problem facing domestic producers, who face the challenge of being competitive with imported beans in terms of price and grain quality. Unfortunately, the prospects for the future are ominous. Starting in 1994, bean import quotas negotiated under the NAFTA have been increasing by 3% annually and import tariffs have been decreasing.

Table 3.2 Imports, Exports, and Net Imports of Dry Beans in Mexico, 1991-2000.

Year	Imports Mt	Exports Mt	Net imports Mt	Percent of total production
1991	30,080	420	29,660	2%
1992	2,909	17,710	-14,801	-2%
1993	7,571	7,309	262	0%
1994	57,510	99,870	-42,360	-3%
1995	26,062	82,872	-56,810	-4%
1996	130,780	9,017	121,763	9%
1997	90,161	7,256	82,905	9%
1998	202,005	5,688	196,317	16%
1999	128,028	8,446	119,582	11%
2000	87,661	7,091	80,570	7%
Average	76,277	24,568	51,709	4%

Source: Computed with data from FAO (2002a).

Furthermore, from 1994 to 1999 bean imports equaled 100% or more of the quota. In addition, the governments of the states of Chihuahua and Durango have complained of illegal entry of dry beans into Mexico via smuggling. These phenomena have further reduced the price of dry beans in the domestic market and have increased the problems the farmers face in marketing domestic production. Clearly, these trends indicate Mexican farmers are becoming less competitive, compared to U.S. bean growers.

By 2008, tariffs on imported beans will be eliminated among the countries that are members of NAFTA. However, this is not the only factor that reduces the competitiveness of Mexican producers. In addition, export subsides to producers in the

U.S., and loans that the U.S. provide to importing countries make it even more difficult for Mexican bean farmers to compete with U.S. producers. Thus, if there are no improvements in increasing bean productivity and marketing efficiency in the future, Mexico will depend mainly on imports to meet domestic demand, which will have a negative impact on rural income and employment in the main bean producing regions of the country—especially in northern Mexico.

3.2 Characteristics of Demand

Dry beans are a traditional staple food in Mexico, especially for low-income people in rural and urban areas. Several factors play a key role in determining the level of demand for beans, including the income levels, the degree of urbanization, and relative prices[4]. During the past twenty years, Mexico has experienced both rapid urbanization and transformation from a mainly traditional agricultural society into a modern industrial society. While around 66% of the country's population lived in urban areas in 1980, by 2000 this share increased to 74%. Similarly, per capita income has increased from US$ 3,029 in 1980 to US$ 5,758 in 2000 (IPED 2002).

3.2.1 Changes in Preferences

This trend—and the integration of Mexico into a global economy—has brought about significant changes in the food economy, including consumer's preferences for dry beans and value-added bean products.

[4] In Mexico, consumers in different parts of the country have strong preferences for specific market classes of beans (black, light-color, or pinto beans). Thus, producing more beans is not enough to satisfy the demand by market class. In recent years, there has been an imbalance between the supply and demand for specific market classes, which remains an important unsolved problem.

First, wealthier and more urbanized consumers are demanding higher quality beans. For example, it is increasingly important that the beans they purchase are fresh because the fresher the beans, the less time is required for cooking. In order to satisfy consumers' preferences for high quality beans, baggers are adding value by grading for quality (homogeneous in color and shape, cleaned, polished and recently harvested), packing their product in plastic bags, and marketing their brand through supermarkets. However, beans are still commonly sold in bulk in traditional markets and increasingly in some supermarkets.

Second, dry beans require a relatively long time to cook. With the increasing participation of women in the labor market[5], working women have less time to cook. As a result, women are increasingly looking in the market for "convenient products" (*i.e.*, products that are easy to prepare or almost ready for consumption). In response to changing consumer preferences, processors are developing new and highly convenient presentations, not only beans in plastic bags but also precooked, canned, and dehydrated bean products.

Clearly, urbanization and income growth are having an important impact on consumer preferences for new, more healthy, and convenient products, of standardized quality. One implication is that increasingly, value is being added to beans after they are marketed by farmers.

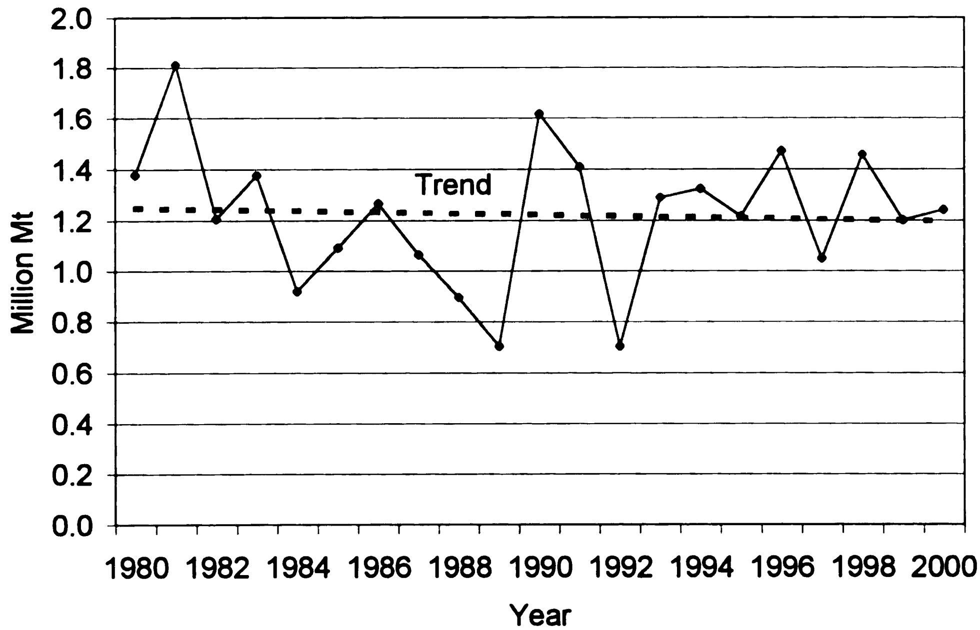
3.2.2 Apparent Consumption

Apparent consumption in Mexico (*i.e.*, computed as production plus imports minus exports) has fluctuated greatly over the 1980-2000 period (Figure 3.7). This erratic

[5] The female participation rate increased from 27% in 1980 to 33% in 1999 (World Bank 2002).

pattern can be explained mainly by the characteristics of the domestic supply, which depends primarily on weather conditions. However, apparent consumption is also affected by changes in the population, the patterns of trade, consumer preferences, and consumer's purchasing power.

Figure 3.7 Apparent Consumption of Beans in Mexico, 1980-2000.



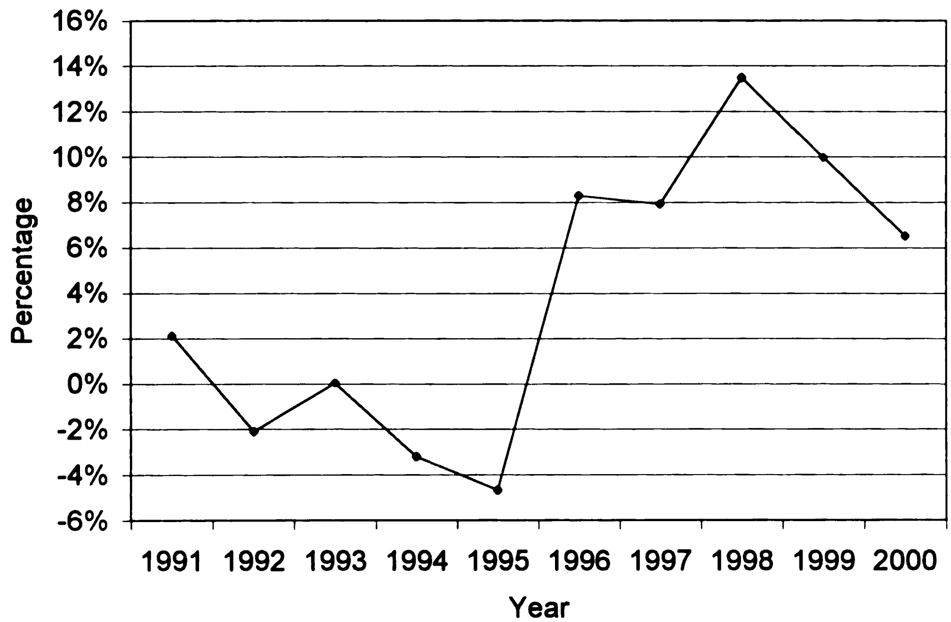
Source: Appendix C.

Although Figure 3.7 indicates a slightly downward trend in total consumption, apparent consumption averaged 1.2 million Mt a year in the 1990s, which was about the same as the average in the 1980s. However, although total apparent consumption has remained essentially unchanged over the twenty-year period (1980-2000), Mexico's population has increased from 67.5 million in 1980 to 98.8 million in 2000. Thus, per capita bean consumption has decreased by 18.5% during the period, as discussed in section 3.2.3.

In years like 1981 and 1990, the high level of the apparent consumption was primarily due to two factors: the large quantity of beans imported during those years, and in these years domestic production was higher than the average level. Furthermore, in both of these years, domestic production in the previous year (*e.g.*, 1979 and 1989) was far below the average (-40% approximately), which explains the high levels of imports the subsequent years (Appendix C).

It is important to highlight that during 1990-2000, Mexico experienced a bean deficit. In seven of the past ten years, total consumption exceeded domestic production. As a result, during the 1990s the size of the deficit, measured by the relative importance of bean imports, increased dramatically (Figure 3.8).

Figure 3.8 Net Imports as a Percentage of Apparent Consumption in Mexico, 1991-2000.



Source: Computed with data from FAO (2002a).

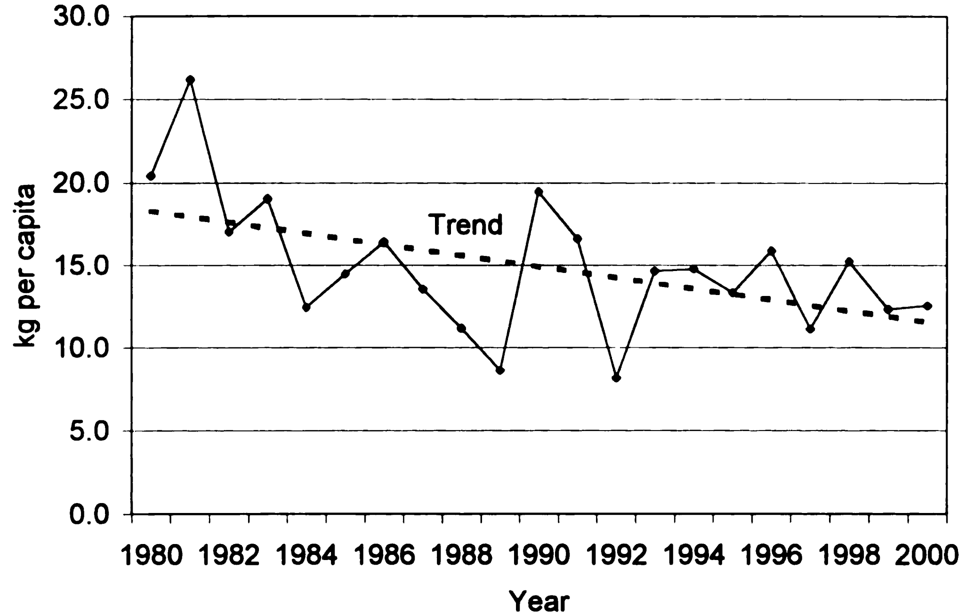
For example, net imports (*i.e.*, computed as total imports minus total exports) as a percentage of total consumption switched from very low or negative levels in the early 1990s, to positive and relatively large percentages of total apparent bean consumption in the late 1990s.

3.2.3 Bean Consumption Per Capita

Among the countries in the Americas, Mexico has one of the higher levels of per capita bean consumption. However, despite year-to-year variations (Figure 3.9) bean consumption per capita decreased from and average of 16.2 kg per year during 1980-1990 to 13.2 kg per year during 1991-2000—which in relative terms means a decrease equal to 18.5% in bean consumption per capita when comparing the average of the second period versus the average of the first period. Thus, in the 1990s, per capita consumption fell at an annual rate of -3%, while other countries in the Americas were still experienced positive growth rates[6].

[6] In the U.S., per capita bean consumption averaged seven pounds (1990-2000), and grew at an average annual rate of 3.6% during the decade of the 1990s. Bean consumption per capita is expected to continue to increase due to the rapid increases in Hispanic population growth rate and because for many immigrants who are from Central American and Mexico, beans are a important part in their traditional diet. In contrast, per capita consumption in Brazil averaged 18 kg during the same period and grew at an annual growth rate of 1% during the 1990s (FIRA 2001).

Figure 3.9 Bean Consumption Per Capita in Mexico, 1980-2000.



Source: FAO (2002a).

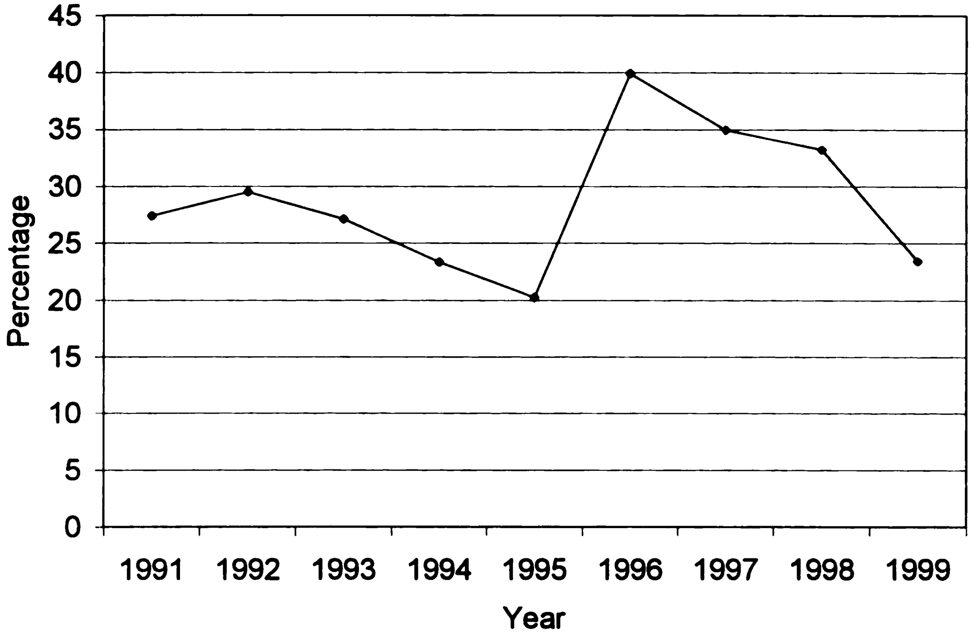
Most of the decline in the per capita consumption has occurred in urban areas, as indicated by the fact that in 1999, the estimated consumption per capita for the rural population (16.8 kg) was 97.6% higher than for urban population (8.5 kg) (SAGAR 2000).

The decreasing share of the rural population in Mexico's total, as result of the process of urbanization, and the different preferences of urban consumers compared to rural consumers are important factors that explain why consumption per capita has been decreasing in recent years and will likely continue to decline in the future.

In addition, the decrease in bean consumption per capita can be partially explained by the increase in the relative price of beans, as a percentage of the daily minimum wage (Figure 3.10). During 1991-1995, the price of one kilo of beans averaged

25.5% of the minimum wage, but during 1996-1999, the relative price of one kilo of beans averaged 32.8% of the daily wage.

Figure 3.10 Price per Kilo of Beans, as a Percentage of Mexico's Daily Minimum Wage, Mexico 1991-1999.



Source: FIRA (2001).

Other factors explaining declining per capita bean consumption are related to changes in consumer preferences (see section 3.2.1), which has led to a reduction in the share of the consumer's budget spent on agricultural products and staple food (*i.e.*, beans) as income per capita increases[7]. Therefore, while Mexico's population has increased from 83 to almost 99 million in 1990-2000 (Table 3.3), total apparent consumption has

[7] This is associated with Engel's Law, which holds that as income rise, demand for the products of the agricultural sector will rise, but more slowly than income (households devote a smaller percentage of their income to food), and with Bennet's Law, which states that households switch from less to more expensive calorie consumption, such as from coarse grains to meats and fresh fruits and vegetables, as incomes rise (value-added foods become a larger part of the household budget than staple foods).

remained relatively constant around the mean of 1.2 million Mt per year as a consequence of the declining per capita consumption.

Table 3.3 Bean Consumption Per Capita in Mexico, 1990-2000.

Year	Population Thousands	Apparent Consumption Million Mt	Consumption per capita kg/ha
1990	83,226	1.618	19.4
1991	84,801	1.408	16.6
1992	86,386	0.704	8.1
1993	87,976	1.288	14.6
1994	89,564	1.322	14.8
1995	91,145	1.214	13.3
1996	92,718	1.471	15.9
1997	94,281	1.048	11.1
1998	95,831	1.457	15.2
1999	97,365	1.200	12.3
2000	98,872	0.964	9.7

Source: FAO (2002a).

3.2.4 Consumption by Market Class

As noted previously, preferences for different market classes vary greatly between regions of Mexico. Regional consumption preferences for different bean market classes were identified through a survey (n=1,514) conducted by scientists of the INIFAP (Castellanos 1996). The study divided the country into four regions, plus the Federal District of Mexico City (Table 3.4). The results indicated that in the North West, 98% of the surveyed individuals preferred the "azufrado" type (sulphur yellow); in the North East, 70% preferred "pinto" (beige with brown mottles) and "bayo" (cream) types; in the South 90% preferred "black" type; in the Central region 34% preferred "Flor de Mayo" (beige with pink mottles) type (although other commercial classes are also widely consumed); and in the D.F. (Mexico City), although there existed diversity in the kind of beans preferred by consumers, 45% preferred the "black" type.

Table 3.4 Preferences for Bean Commercial Classes by Region in Mexico, 1993-1994.

Commercial Class	Northeast (%)	Northwest (%)	Central (%)	South (%)	D.F.[a] (%)
Black	0.5	0.0	10.9	90.0	44.6
Azufrado	5.4	97.5	13.7	2.1	9.5
Bayo	25.3	0.8	9.5	5.7	10.1
Pinto	44.8	0.4	1.9	0.0	2.7
Flor de Mayo	11.3	0.0	33.7	0.0	12.0
Flor de Junio	0.0	0.0	21.0	0.0	6.8
Other	12.7	1.3	9.3	2.2	14.3
Total	100.0	100.0	100.0	100.0	100.0

a. The D.F. refers to the Federal District of Mexico City
Source: Castellanos (1996).

A more recent study (FIRA 2001) examined production, consumption, and balance (*i.e.*, production minus consumption) of dry beans by market class for the 32 states in Mexico. Three market class were defined, based on their color (Table 3.5): "black" beans (Jamapa, San Luis, Michigan, Nayarit and Altiplano; "light" beans (Flor de Mayo, Flor de Junio, Garbancillo, Azufrados, Canario, and Amarillo); and "pinto" beans (Pinto Americano, Pinto Nacional y Ojo de Cabra). This study estimated that whereas there was a surplus of "light" beans, there also was a large deficit for "pinto" and "black" beans. As a result, Mexico had an overall average annual net deficit of approximately 28,300 Mt during 1993-1999, which had to be met via imports.

Pinto Beans

In 1993-1999, pinto beans accounted for an average of 25% of national production. The most important producers of pinto beans were the states of Chihuahua

(37%), Durango (33%), and Zacatecas (12%), which produce approximately 82% of domestic production of pinto beans. The center, north, and northeast regions of the country were the most important consumers of this market class, especially the states of Mexico (13%) and Chihuahua (12%).

Table 3.5 Annual Apparent Consumption by State and Market Class, Mexico 1993-1999.

State	Consumption (Mt)			Production (Mt)			Difference (Mt)		
	Black	Light	Pinto	Black	Light	Pinto	Black	Light	Pinto
Chiapas	41,957	5,199	5,199	56,196	3,128	3,127	14,239	-2,071	-2,072
Chihuahua			42,783			114,833			72,050
D.F	53,921	32,352	21,569	353			-53,568	-32,352	-21,569
Durango		9,832	14,752	15,000	9,000	102,714	15,000	-832	87,962
Guanajuato	6,088	30,436	24,349	1,244	39,331	9,435	-4,844	8,895	-14,914
Jalisco	7,935	47,609	23,804		21,366	4,114	-7,935	-26,243	-19,690
Mexico	65,692	49,269	49,269	10,932	3,000	1,500	-54,760	-46,269	-47,769
Nayarit		10,726	2,682	59,983	21,994	876	59,983	11,268	-1,806
Nuevo L.		24,014	24,015		934	2,618		-23,080	-21,397
Sinaloa		28,164	7,042		189,064	1,855		160,900	-5,187
Veracruz	69,299	8,664	8,664	20,029	3,004	2,223	-49,270	-5,660	-6,441
Zacatecas		20,338	13,560	113,627	176,977	37,876	113,627	156,639	24,316
Subtotal	244,892	266,603	237,688	277,364	467,798	281,171	32,472	201,195	43,483
Other	148,144	233,234	132,221	83,343	98,118	26,603	-64,801	-135,116	-105,618
Total	393,036	499,837	369,909	360,707	565,916	307,774	-32,329	66,079	-62,135

Source: FIRA (2001).

Pintos are the market class with the largest annual deficit (62,135 Mt), accounting for 66% of the total domestic annual gross deficit (94,464 Mt) during 1993-1999. The states having the major deficit of pinto beans were Mexico, Mexico D.F., Nuevo Leon, Jalisco, and Guanajuato. In addition to interregional sales, Mexico has consistently imported pinto beans to meet consumer demand.

Black Beans

During 1993-1999, black beans accounted for an average of 29% of national production. The most important producers of black beans were the states of Zacatecas

(32%), Nayarit (17%), and Chiapas (16%), which produce approximately 65% of domestic production of black beans. The center and the south regions of the country were the most important consumers of this market class, including the states of Veracruz (18%), Mexico (17%), and Mexico D.F. (14%). Black beans are the market class with the second largest annual deficit (32,329 Mt), accounting for 34% of the total domestic annual gross deficit (94,464 Mt) during 1993-1999. The states having the major deficit of black beans were Mexico, Mexico D.F., and Veracruz. In addition to interregional sales, Mexico has consistently imported black beans to meet consumer demand.

Light Beans

Light color beans accounted for an average of 46% of national production during 1993-1999. The most important producers of light color beans were the states of Sinaloa (33%), Zacatecas (31%), and Guanajuato (7%), which produce approximately 71% of domestic production of light beans. The center and northwestern regions of the country were the main consumer of this market class, especially the states of Mexico (10%), Jalisco (9.5%), Mexico D.F. (6.5%), and Guanajuato (6%).

Because demand for these beans is low in the north, northeast, and south of the country it is difficult for farmers to sell all their light color beans in the domestic market. As a result, there has been an annual surplus of approximately 66,079 Mt (12% of light beans production). To market the surplus of this market class—in addition to sales to other regions in the country and the regulation of the supply over time by storing the beans—export sales and sales to the food industry have been important channels for marketing light color beans.

The results in the study executed by FIRA (2001) basically agree with the findings in the Castellanos study (1996) regarding the preferences for different market classes of beans (pinto, black, and light color beans) in the most important regions of the country.

3.3 Characteristics of Prices

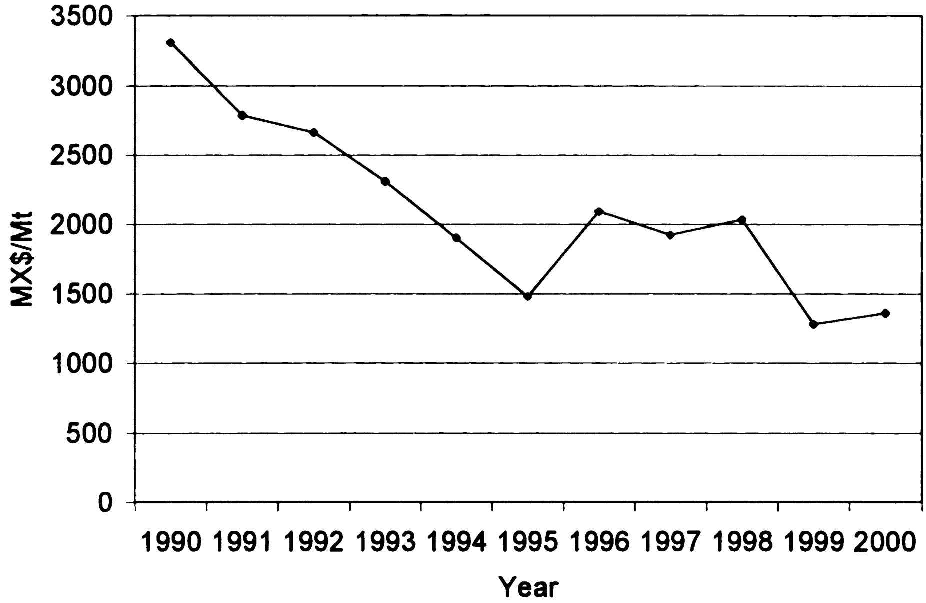
Producer and wholesale bean prices vary greatly over time and according to market class. The highest price is for the first-class quality (cleaned, selected, sifted, polished, and fresh) and the most preferred market classes (*e.g.*, Flor de Mayo, Flor de Junio, Negro Jamapa or Azufrados). The lowest price is for low quality beans (broken, stained, mixed color, old hard-to-cook beans), and the nonpreferred market class (*e.g.*, Ojo de Cabra).

3.3.1 Real Bean Prices

Real Producer Prices

Real producer prices for beans declined drastically during the 1990s. From 1990 to 2000, the price fell continuously from MX$ 3,307 (base-year=1994) to MX$ 1,360 per Mt (Figure 3.11), which implies a reduction in value of 58.9% in only 10 years. During the period, the price was lowest in 1999 (MX$ 1,279 per Mt). This drop in the real bean price is associated with price liberalization, which is designed to set prices in the domestic market to reflect the prices in the world market, where bean prices have been declining.

Figure 3.11 Real Producer Prices for Beans in Mexico, 1990-2000.
(Base-year=1994)



Source: Appendix D.

Also, under the NAFTA, the establishment of higher import quotas and lower tariffs on imported beans has made it possible to import beans at a lower price than before. The market classes imported beans have been mainly pinto and black beans.

<u>Real Wholesale Prices by Market Class</u>

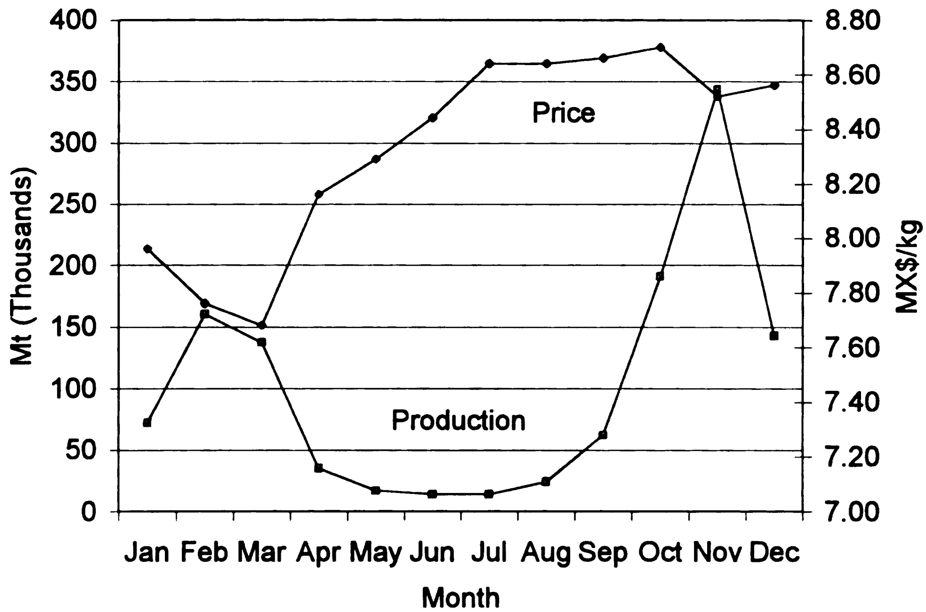
In the wholesale market, the decline in real prices has affected all market classes. For example, in the central market of Mexico D.F., the most important central market in Mexico, the real wholesale price for beans decreased from 1991 to 2000 for both domestic and imported beans (base-year=1998). In general, domestic pinto beans have faced the greatest real price decrease—from MX$ 8.50 in 1991 to MX$ 4.00 per kg in 2000 (-53%). During the period, the price of imported pinto beans (Pinto Americano) was approximately 15% higher (on average) than that of domestic pinto beans (Pinto

Nacional). In contrast, the price of domestic black beans (the market class with the smallest price decline) decreased from MX$ 9.00 in 1991 to MX$ 7.00 per kg in 2000 (-22%). During the period, the price of imported black beans (Negro Michigan) was approximately 20% higher (on average) than that of domestic black beans (Negro Nayarit). Domestic light color beans (Azufrado y Peruano) experienced a price decrease —from MX$ 8.00 in 1991 to MX$ 6.00 per kg in 2000 (-25%) (FIRA 2001).

3.3.2 Wholesale Price Seasonality

By observing the variations of both production and nominal wholesale prices through the year, price seasonality can be related to fluctuations in domestic production over the year. During 1990-1999, monthly average prices and production showed an inverse relationship (Figure 3.12). In general, prices trended upward from April to October, which is the period of the year when the supply of domestic beans decreases considerably. In contrast, prices declined during February-March, and in November, which is the period of the year when there is usually a surplus of domestic beans in the marketplace.

Figure 3.12 Bean Wholesale Price Seasonality in Mexico, 1990-1999.



Source: SAGAR (2000).

However, a closer review of monthly production and price statistics shows that while monthly production is highly variable, prices fluctuate much less. During the 1990-1999 period, production averaged 101 Mt per month, with a standard deviation of 99.2 Mt and a coefficient of variation of 98%, which indicates a large variability in the amount produced each month (Table 3.6). On the other hand, prices averaged MX$ 8.3 per kg, with a standard deviation of MX$ 0.36/kg and a coefficient of variation of only 4%. This shows that throughout the year the variation in price is relatively small. For example, over the year the highest monthly price (MX$ 8.70) and the lowest monthly price per kilo (MX$ 7.68) differed only by 13%. This implies that although domestic production is highly variable, the marketing system has been relatively efficient in terms of coordinating bean supply and demand through the year and in keeping prices relatively stable.

Table 3.6 Bean Wholesale Price Seasonality in Mexico, 1990-1999.

Month	Price MX$/kg	Production 000 Mt
Jannuary	7.96	72
February	7.76	160
March	7.68	137
April	8.16	35
May	8.29	17
June	8.44	14
July	8.64	14
August	8.64	24
September	8.66	62
October	8.70	191
November	8.52	343
December	8.56	143
Average	8.33	101

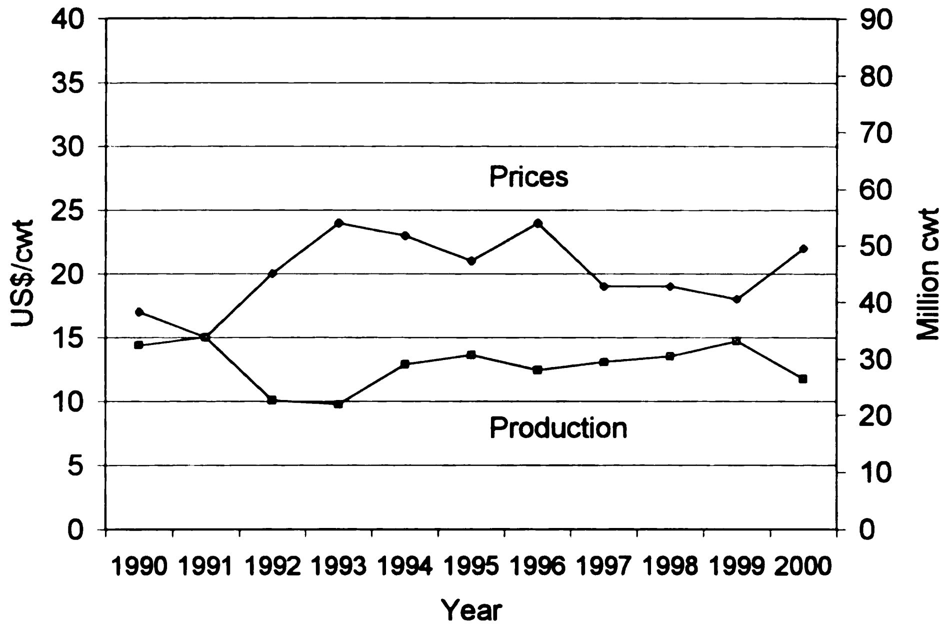
Source: SAGAR (2000).

3.3.3 International Prices

The observed price decline for beans in the domestic market is related to the decreasing trend in international market prices. For example, in the U.S., which is Mexico's most important source of imported beans, prices for beans in the late 1990s were lower than the prices in the in the mid 1990s (Figure 3.13). In contrast, U.S. bean production was higher in the late 1990s than in the early 1990s, as a result of an increase in yields, while the acreage remained relatively constant (ERS 2002a, 2002b). This increasing trend in productivity and bean production explains the decreasing trend in prices.

In addition, fluctuations in prices are related to fluctuations in dry bean production. Figure 3.13 shows that higher prices are associated with lower levels of production during the period (*e.g.*, 1993 and 1996) and that lower prices are associated with higher levels of production during the period (*e.g.*, 1991 and 1999).

Figure 3.13 Dry Beans: U.S. Production and Grower Price, 1990-2000.



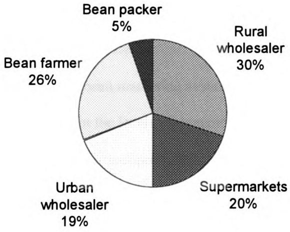
Source: ERS (2002a).

3.3.4 Marketing Margins

Due to high marketing margins, there is a big difference between the price paid by the consumer and the price received by producer. FIRA (2001) estimated that for domestic beans, the rural wholesaler gets the largest share (30%) of the final consumer price (Figure 3.14), followed by farmers (26%), supermarkets (20%), urban wholesaler (19%), and packers (5%).

In the case of imported beans (black and pintos), the largest share of the consumer price goes to the urban wholesaler, which makes it more profitable for wholesalers to buy imported beans instead domestically-produced beans. For example, FIRA (2001) estimated that in 1999 the urban wholesaler's marketing margin for imported beans was 36% versus 19% for domestic beans. The fact that import quotas limit the amounts of beans that can be imported is an important factor explaining this difference.

Figure 3.14 Marketing Margins for Domestic Beans in Mexico, 2000.



Source: FIRA (2001).

Both the high concentration of large purchasing firms in the bean market (see section 3.4.2), and the development of alliances to facilitate importing beans, have led to a further reduction in costs and higher profits for these few large firms. In addition, according to the rules of the NAFTA, the expectation is that bean imports from the U.S. will continue their increasing trend, as a result of scheduled (legally mandated) increases in import quotas and decreases in import tariffs.

3.4 Bean Marketing System

One of the most important problems facing the bean subsector in Mexico is marketing. This is related not only to the complexity that arises from the diversity of demand for different market classes and quality of beans in regional markets, but is also due to the high level of concentration in the wholesale bean market, which results in large commissions to brokers, which in turn results in lower prices to producers and higher prices to consumers. In addition, the market also faces the challenge of adjusting to price liberalization and reduced government intervention.

3.4.1 Bean Marketing System

For many years, the bean marketing system in Mexico has been inefficient, due to the lack of information about the levels of demand and the preferences of consumers in regional markets, the low quality of product presentation, and a lack of appropriate marketing strategies. For example, farmers primarily market their beans in bulk (sacks of 50, 70, and 90 kg) without any previous selection or cleaning. As a result, middleman pay farmers a low price. In addition, farmers receive low price because they are not organized to negotiate better price and selling conditions.

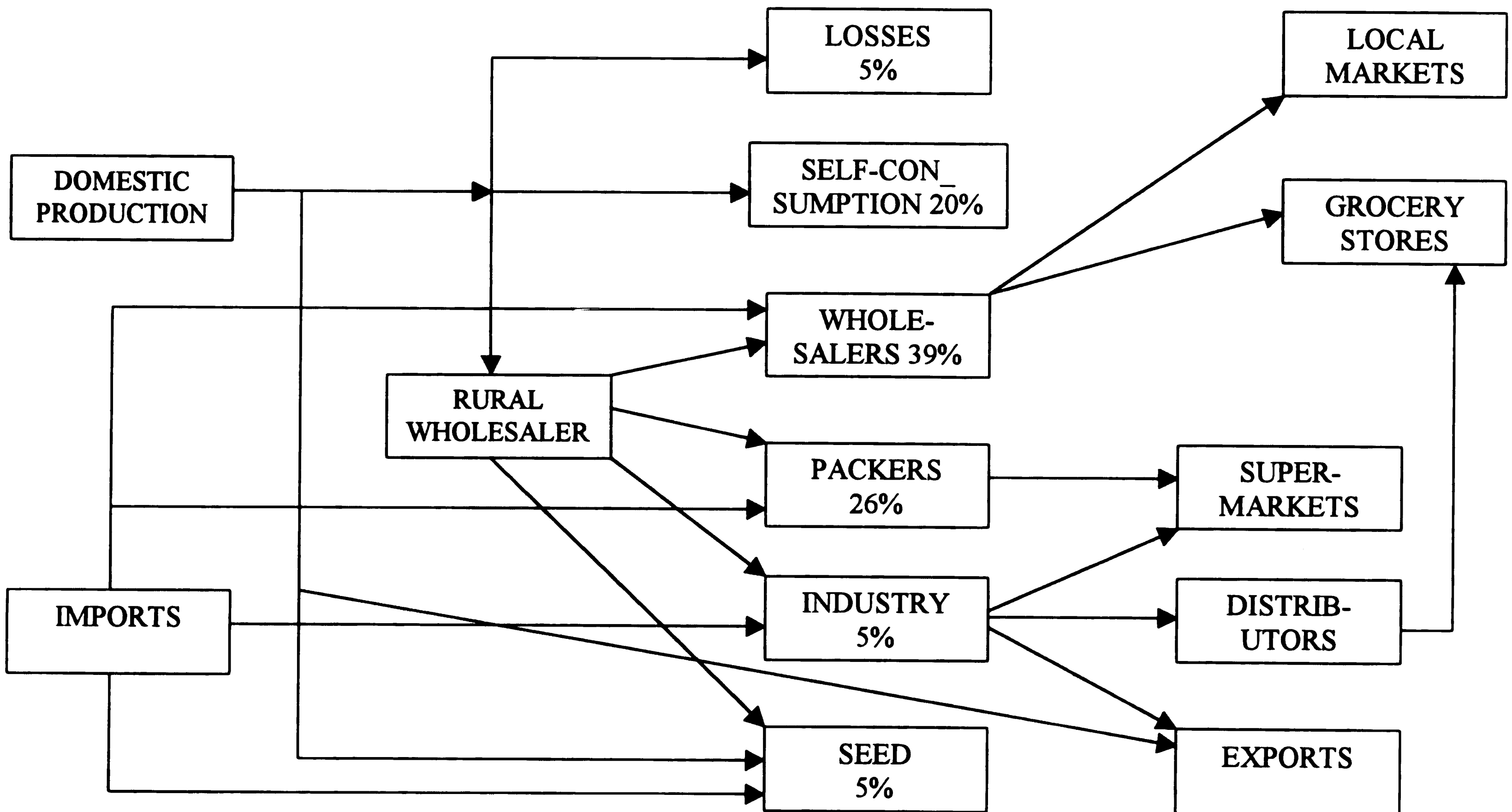
For several decades the parastatal CONASUPO played a major role in marketing many agricultural products including beans. Among other functions, CONASUPO was in charge of regulating the supply and demand for beans in the domestic market. In addition, it was solely responsible for importing beans to cover the deficit in domestic production. During the 1980s, CONASUPO marketed approximately 40% of total bean domestic production. In the late 1990s, the process of opening up trade with the U.S. and Canada and price liberalization led to the dismantling of CONASUPO. Since the closure of CONASUPO in 1999, which previously intervened in corn and dry bean markets, the government has allowed prices to be set by free market forces.

Four factors have constrained bean marketing in the late 1990s. First, due to the long distances between the production areas and the main consumption areas, transportation costs are high. For instance, for the case of the production areas of Sinaloa and Zacatecas, the distance by railroad to Mexico City is 1,411 and 855 km, respectively, while the highway distance is 1,266 and 783 km, respectively, but the cheapest means of transport is the railroad. Second, there are large commissions to brokers that affect both producers and consumers. As a result, farmers receive a lower price for their harvest and consumers have to pay a higher price for beans. Third, some of the preferred market class beans have been displaced in the field by new improved varieties that are higher yielding varieties and disease or pest resistant, but these varieties are not preferred by consumers. Fourth, the government has provided few supports for marketing domestically-produced beans in the local market. For example, after the elimination of guaranteed prices and the closure of CONASUPO in the late 1990s, farmers had limited access to infrastructure (mainly post-harvest infrastructure like storehouses and vehicles) and services to support them in marketing their production, which reduced their ability to compete with bean private traders—who had more resources available to market beans.

3.4.2 Bean Marketing Channels

The main bean-marketing channels in Mexico and the estimated percentage of the product that is marketed through each channel are shown in Figure 3.15. Currently, an estimated 20% of production is utilized for self-consumption, 5% are losses due to spoilage during storage and transportation, and 5% is saved for seed. Therefore, approximately 30% of production does not enter formal marketing channels. This share for self-consumption includes varieties that satisfy very specific niche markets.

Figure 3.15 Bean Marketing Channels in Mexico, 1999.



Source: FIRA (2001).

The most important varieties in this category are the "ibes" from Yucatan and Chiapas, the "espelon" of Yucatan, the "combas" of Guerrero, the "ayacotes" of Morelos and many other less important bean varieties.

The initial marketing channel for domestic beans are rural wholesalers (middleman) with a large storage capacity, as well as many low volume buyers who serve local markets. As small farmers are not organized to market their production and since bean supply is very dispersed, the middlemen play an important role in gathering small amounts of production and concentrating them in quantities that are large enough to be marketed to the urban wholesalers, packers, and processors.

Very few of the middlemen add value to beans (*i.e.*, packing and processing), although the bulking and spatial concentration of beans is a value-adding activity. Rather, most of them just sell the beans in bulk, and only in a few cases the beans are packed by the middlemen. It is primarily the packer who carries out selecting and cleaning.

FIRA (2001) estimates that the middlemen purchase 70% of domestic production, which they sell to wholesalers, packers, and processors. Processors commonly buy the beans once that have been cleaned and residuals like stones, dust, straw and other foreign matter has been removed. About 39% of domestic production is marketed through wholesalers at central markets, while packers and processors purchase 26% and 5%, respectively. Both wholesalers and processors import beans, although the former account for the majority of imports (80%).

There is a high degree of concentration in dry bean marketing in Mexico. According to FIRA (2001), approximately 60% of the marketed production is purchased by only 16 firms that procure nationwide (seven firms purchase 40% of marketed production). This means that the market for beans has the behavior of an oligopsony. These few buyers have considerable market power, while the many small, dispersed and unorganized producers have little bargaining power. As a result, bean farmers receive lower prices and consumers pay higher prices than would be the case under a more competitive marketing structure.

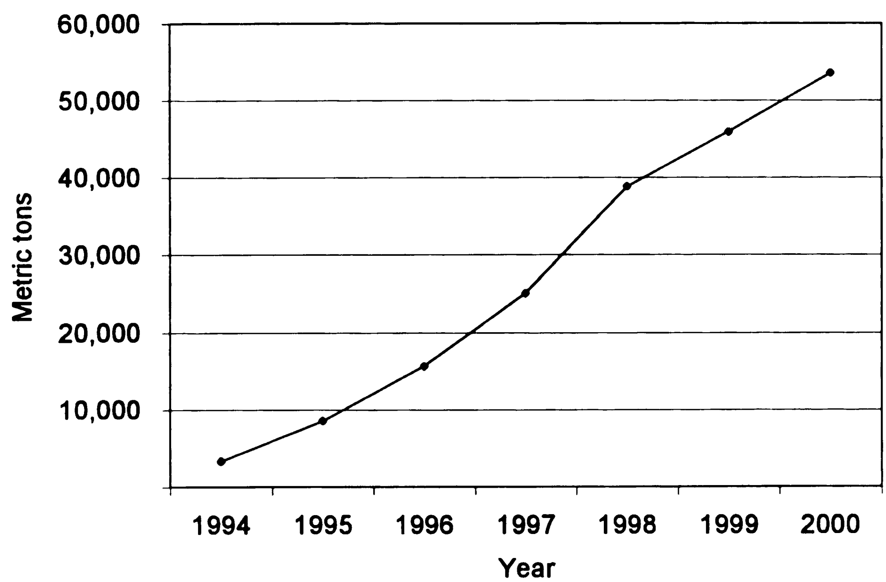
Consumers buy dry beans in the county market, traditional markets (tianguis), grocery stores, or at the self-service retail market (*e.g.*, supermarkets). During 1994-1999, grocery stores sales decreased by 8% in real terms and local and traditional markets sales declined slightly. In contrast, during this period the supermarkets increased their sales by 20%. This is because supermarkets offer better services to consumers in terms of the diversity of the product, shopping hours, location, and comfort. In addition, supermarkets sell beans at the same or even lower prices than other kind of stores. However, according to consumer surveys, people believe that beans in plastic bags are not as fresh as beans sold in bulk at traditional markets (FIRA 2001).

3.4.3 Bean Processing Industry

Value is added to beans through packing and the manufacturing of processed products. The packing industry adds a small amount of value-added to the primary product by cleaning, selecting, grading, polishing, and packing beans. While these operations do not significantly modify the product, they generate the kind of product that is increasingly being demanded by consumers (a clean and homogenous product). The packing industry is located in the close proximity to the most important central markets (D.F., Estado de Mexico, Jalisco, and Nuevo Leon). Packers prefer these locations because large amounts of beans are available in these centers and they are near the packers' primary sales outlets—mainly supermarkets in densely populated urban areas.

The processing industry, which is concentrated in the states of Nuevo Leon, San Luis Potosi, Aguascalientes, Estado de Mexico, and D.F., primarily produces canned and dehydrated beans. A few years ago, few Mexican consumers bought processed beans. However, since 1994 the production of processed beans has increased rapidly—3,314 Mt in 1994 to 53,515 Mt in 2000 (Figure 3.16). This 16.2 fold increase represents an average annual growth rate of 59% over the period.

Figure 3.16 Production of the Bean Processing Industry in Mexico, 1994-2000.

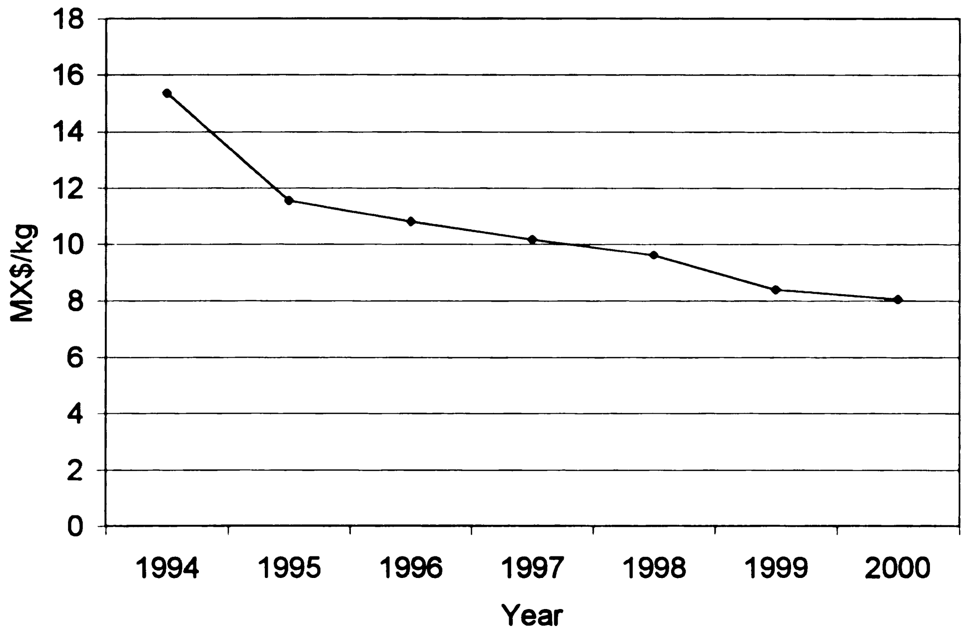


Source: FIRA (2001).

Over the period 1994-2000, the bean processing industry has been able to reduce its unit cost of production from MX$ 15/kg to MX$ 8/kg in real terms, with 2000 as the base-year (Figure 3.17). This increase in efficiency has enabled processors to offer the final consumer processed bean products at lower price. Although processed beans represent only 4.5% of apparent consumption, this percentage is increasing rapidly due to changes in consumer preferences.

According to FIRA (2001), currently only 5% of the total production of beans is processed, while 26% of domestic production is cleaned and packed by the packing industry. In general, processors purchase beans from the wholesalers, although in some cases they attempt to buy directly from the producers in order to reduce costs of purchasing and thereby be more competitive.

Figure 3.17 Real Cost of Processing Beans by the Industry in Mexico, 1994-2000. (Base-year=2000)



Source: FIRA (2001).

The processing industry is primarily interested in purchasing beans in bulk at a low price, rather than purchasing high quality beans. In fact, processors prefer low quality beans (old, broken, stained) in order to reduce their input costs, although for some products whole beans are required. Processors purchase beans in 50 kg sacks, which have been cleaned and sorted by market class. About 40% of Mexico's processed bean output is exported to the U.S. While the processing industry mainly utilizes bayo and black beans, it also utilizes small quantities of other market classes.

3.5 Summary of the Chapter

In Mexico, dry beans are the second most important crop (after maize), both in terms of consumption and production. Mexico is the third largest producer of dry beans in the Americas and has the second largest planted area. During 1996-2000, the total harvested area decreased 2.0% and average yield decreased 2.5% compared to 1990-1995. As a result, production declined 4.5% in 1996-2000 compared to 1990-1995.

In Mexico, beans are grown during two seasons: the spring-summer (SS) season and the fall-winter (FW) season. Most of Mexico's bean crop is grown during the SS season (84% of area and 73% of production). Yields are relatively low during the SS season because beans are grown mainly under rainfed conditions.

Bean production is shifting from the SS season (where area, yields, and production are decreasing) to the FW season, where most beans are grown under irrigated conditions and where the increase in production is due to area expansion, which has offset decreasing national yields and led to a positive increase in annual total production.

Beans planted during the SS season are harvested during September to December, and beans planted during the FW season are harvested during January to April. Thus, beans flood domestic markets during September-December. In contrast, there is a relative scarcity of domestic beans in the market during May to August.

Since Mexico does not produce enough beans to meet its domestic requirements, it has been importing beans (mainly U.S. pinto and black beans) to meet part of the domestic demand. There is an increasing trend in the amount of beans imported, which has resulted in a loss of foreign exchange and highlights the problem for domestic producers, who face the challenge of being competitive with imported beans. In addition, bean import quotas negotiated under the NAFTA have been increasing annually and import tariffs have been decreasing.

During the past twenty years (1980-2000), Mexico has experienced both rapid urbanization and transformation from a mainly traditional agricultural society into a modern industrial society. Urbanization and income growth are having an important impact on consumer preferences. Increasingly, consumers are demanding new, more healthy, and convenient bean products, of standardized quality. One implication is that increasingly, value is being added to beans after they are marketed by farmers.

Although total population increased during 1980-2000, total apparent consumption remain roughly unchanged. Thus, consumption per capita decreased by 18.5% during the period. This is explained by the process of urbanization, changes in consumer preferences, and the increase in the price of beans relative to the minimum wage.

Although Mexico has a surplus of light color beans, it has a deficit of pinto and black beans. During 1993-1999, pinto beans accounted for an average of 25% of national production. The most important producers of pinto beans were the states of Chihuahua

(37%), Durango (33%), and Zacatecas (12%), which produce approximately 82% of domestic production of pinto beans. Black beans accounted for an average of 29% of national production.

The most important producers of black beans were the states of Zacatecas (32%), Nayarit (17%), and Chiapas (16%), which produce approximately 65% of domestic production of black beans. Light color beans accounted for an average of 46% of national production. The most important producers of light color beans were the states of Sinaloa (33%), Zacatecas (31%), and Guanajuato (7%), which produce approximately 71% of domestic production of light beans.

Real producer prices for beans declined 59% in 1990-2000. This drop in the real bean price is associated with price liberalization, which is designed to set prices in the domestic market to reflect the prices in the world market, where bean prices have been declining.

In the wholesale market, the decline in real prices has affected all market classes. In 1991-1999, domestic pinto beans faced the greatest real price decrease (-50%) followed by light color beans (-25%) and black beans (-22%).

Price seasonality is related to fluctuations in domestic production over the year. During 1990-1999, monthly average prices and production showed an inverse relationship. In general, prices are higher before the SS harvest and lower after the FW and SS season harvest. In addition, in the late 1990s, there was a decreasing trend in the grower price for dry beans in the U.S., which is Mexico's most important foreign source of imported pinto and black beans. If prices remain low, only some areas irrigated or with good rainfed conditions in Mexico will be able to produce beans at competitive prices.

One of the most important problems facing the bean subsector in Mexico is marketing. This is related not only to the complexity that arises from the diversity of demand for different market classes and quality of beans in regional markets, but is also due to the high level of concentration in the wholesale bean market, which results in large commissions to brokers, which in turn results in lower prices to producers and higher prices to consumers.

Value is added to beans through packing and the manufacturing of processed products. The processing industry primarily produces canned and dehydrated beans. Since 1994 the production of processed beans has increased rapidly. About 40% of Mexico's processed bean output is exported to the U.S. Although currently only 5% of the total production of beans is processed and 26% is cleaned and packed, these percentages are increasing rapidly due to changes in consumer preferences.

CHAPTER 4. GOVERNMENT POLICIES AND BEAN SUPPORT PROGRAMS

4.1 Government Agricultural Policies

In order to achieve the national food self-sufficiency, for several decades the Mexican government has implemented different strategies to promote bean production —including input subsidies and support prices. During the first half of the 1980s, bean production increased greatly as result of the "Sistema Alimentario Mexicano" (SAM) program, which emphasized government participation in marketing and price regulation (guaranteed prices). In the early 1990s, the process of price liberalization required the government to develop new strategies to support the agricultural development—mainly through the "PROCAMPO" and "Alianza para el Campo" (Alliance for the Countryside) support programs. Furthermore farmers adoption of improved varieties has been promoted through the Kilo per Kilo program, a component of the Alliance for the Countryside program.

4.1.1 Support Programs

During the decade of 1990s the Mexican government started several new programs to support farmers and raise their standard of living. The “Programa de Apoyo Directo al Campo” (PROCAMPO) provides direct support to farmers, based on their planted area. The objectives of the program are to help farmers make the transition from a government-regulated to a market-driven agricultural sector by compensating them for subsidies provided to farmers in other countries, encouraging the development of farmers’ organizations, and increasing competitiveness in production and marketing. As the direct support is paid per hectare (Table 4.1), the program requires that the plots need to be planted for a farmer to receive the support. The program was designed for 15 years, because the government estimated that this period would provide enough time for farmers to adopt new technologies, get organized, fuse smaller plots, and convert their land to a more productive use.

PROCAMPO, which started in the Fall-Winter season 1993/1994, initially supported farmers growing basic crops (*i.e.*, maize, beans, wheat, and rice). From September 1996 to August 1997, the program supported 13.9 million hectares, paid out MX$ 7,543.7 million (approximately US$ 980 million), and benefited 2.96 million farmers. Approximately 80% of those farmers planted under rainfed conditions (Spring-Summer season). At present, as this support does not depend on the kind of crop being grown, farmers can switch to another crop if it is better suited to the environmental and market conditions.

Table 4.1 Direct Cash Payments of PROCAMPO in Mexico.

Crop Year	MX$/ha	Exchange Rate	US$/ha
1994	350	4.22	83.02
1995	440	6.67	65.98
1996	484	7.62	63.51
1997	556	7.96	69.84
1998	626	9.11	68.70
1999	708	9.84	71.92
2000	778	9.54	81.53
Mean	563	7.85	72.07

Source: SAGAR (2000).

As a complement to PROCAMPO, in 1996 the Federal Government started "Alianza para el Campo" (Alliance for the Countryside), a support program for promoting agricultural production and rural development. Some of the most important components of Alliance for the Countryside that affect agricultural production are the programs Fertigation, Kilo per Kilo, Rural Equipment, Mechanization, Research and Technology Transfer, Integrated Rural Training and Extension, and the Elemental Program for Technical Assistance.

For bean farmers, one of the most relevant components of Alliance for the Countryside is the Kilo per Kilo program, which has the objective to increase yields by promoting technical change (under irrigated as well as rainfed conditions) through the substitution of modern varieties for traditional varieties. Seed of the improved varieties is delivered to farmers at a price equivalent to commercial grain. This significant reduction in price makes improved seed very affordable to farmers. Since its inception, the Kilo per Kilo program has shown positive results. During 1996-1997, more than 100,000 hectares were planted modern bean varieties, resulting in a significant increase in yields —up to 100%—in the lowland and the tropic (SAGAR 1998).

4.1.2 Price Policy

Until 1993, bean prices were determined mainly by the strong intervention of the government through guaranteed prices that gave farmers a minimum revenue which covered their production costs. This system operated via the "Compania Nacional de Subsistencias Populares" (CONASUPO), a parastatal that purchased commodities from farmers. But starting in 1993, the government initiated important changes to promote a higher level of private sector participation in bean marketing. After these changes, CONASUPO's role in the market was relegated to being a buyer of last resort.

Up to the Fall-Winter season 1995/1996, CONASUPO maintained an active participation in the market of grains. Subsequently, it started to reduce its market participation (as part of the government process of deregulation) and began to use the criterium of "minimum buying price". Under this policy, the farm-gate price was established at a level about 40% lower than the price in the central market—a price that was considered as the "lowest price". Once the process of deregulation was initiated, using the "last resort buyer" criterium, CONASUPO's market share fell to around 6% of domestic bean production, with the private sector increasing its participation over time in the marketing process.

Starting in May 1998, CONASUPO stopped buying dry beans and establishing minimum prices. Since then, bean prices have been determined according to a freer interaction of supply and demand in the marketplace. In addition, several services that supported the marketing of agricultural products were taken on by the office "Apoyos y Servicios a la Comercializacion Agropecuaria" (ASERCA). Finally, on May 24th, 1999 a decree that called for closing CONASUPO was published in the Federation Official Diary (DOF).

However, under the new policy of price liberalization, growing beans under rainfed conditions is not sustainable without the direct support of PROCAMPO. In the period 1993-1999, FIRA-Bank of Mexico carried out an annual survey to measure profitability[8] for farmers growing beans under rainfed conditions in Chihuahua, Durango, and Zacatecas; and under irrigated conditions in Sinaloa and Nayarit—the most important states producing beans under each water condition.

[8] Profitability was measured (without including the direct cash payments) by using the ratio: Net Revenue/Cost = N/C = (Revenue-Cost)/Cost. The results from the survey show that during that period, under rainfed conditions, the average N/C ratio (1993-1999) was close to zero. However, it was positive for Chihuahua (0.11) and Durango (0.10), but negative for Zacatecas (-0.12). Under irrigated conditions, the average N/C ratio (1993-1999) was slightly positive and higher for Sinaloa (0.34) than for Nayarit (0.27). When PROCAMPO payments were included in the analysis the average N/C ratio for Zacatecas (under rainfed conditions) changed from -0.12 to 0.28 on average over the 1994-1999 period (FIRA 2001).

The results of the study show that without the PROCAMPO payment, bean production is sustainable only under irrigated conditions or in areas with good rainfed conditions and high yields[9].

4.1.3 Trade Agreements

While Mexico has signed trade agreements with different countries, the most important agreement (for most of products including dry beans) has been the North American Free Trade Agreement (NAFTA) to which Canada, Mexico and the U.S. are signatories. Under NAFTA, which came into force in 1994, three different categories were established: "beans for seed" (code 0713.33.01), "beans except for seed" (code 0713.33.02) for the most important market classes, and "other" (code 0713.33.99) for other bean market classes. "Beans for seed", was tariff-exempt before the agreement. The "other" was made tariff-exempt as soon as the agreement started. For "beans except for seed", the agreement established that it would become tariff-exempt over a fourteen-year period—starting with a tariff of 133.4% *ad valorem* and a tariff-exempt import quota of 51,500 Mt (50,000 for the U.S. and 1,500 for Canada). For both Canada and the U.S., an annual increase of 3% in the import quota was established. By 2008, dry beans will be tariff-exempt and they will be imported freely. The phase-out tariff schedule and tariff-exempt quotas for importing dry beans into Mexico, as agreed to under the NAFTA, are shown in Table 4.2.

[9] Under rainfed conditions, average cost of production averaged MX$ 2,270 per ha in 1999 (around US$ 231), whereas yield averaged 420 kg per ha in 1993-1999, which implies a unit cost of US$ 550 per Mt. Under irrigated conditions, cost of production averaged MX $4,397 per ha in 1999 (around US$ 447), and yield averaged 1,595 kg/ha in 1993-1999, which implies a unit cost of US$ 280 per Mt (FIRA 2001).

Table 4.2 Phase-out for Bean Import Tariffs and Quotas under the NAFTA.

Year	Tariff	U.S. (Mt)	Canada (Mt)	Total (Mt)
1994	133.4%	50,000	1,500	51,500
1995	127.8%	51,000	1,545	53,045
1996	122.3%	53,045	1,591	54,636
1997	116.7%	54,636	1,639	56,275
1998	111.2%	56,275	1,688	57,964
1999	105.6%	59,964	1,739	59,703
2000	93.9%	59,703	1,791	61,494
2001	82.1%	61,494	1,845	63,339
2002	70.4%	63,339	1,900	65,239
2003	58.7%	65,239	1,957	67,196
2004	46.9%	67,196	2,016	69,212
2005	35.2%	69,212	2,076	71,288
2006	23.5%	71,288	2,139	73,427
2007	11.1%	73,427	2,203	75,629
2008	0.0%	No quota	No quota	No quota

Source: FIRA (2001).

From 1994 to 1999, bean imports from the U.S. and Canada were only lower than the NAFTA established quota in 1995. In 1996 and 1998, imports were 123% and 190% higher than the quota, respectively (Table 4.3). The significant increase in the amount imported in 1996 was due to a shortage of beans in the domestic market, which by October 1996 led to a price increase of 63.3% for pinto beans and 80% for black beans, with respect to the price level of January 1996 (SAGAR 1998, 2000).

Table 4.3 Imports from U.S. and Canada as a Percentage of the NAFTA Import Quota.

Item	1994	1995	1996	1997	1998	1999	2000 p/
Imports	50,725	25,538	121,687	55,987	168,262	60,998	21,085
Quota	51,500	53,045	54,636	56,275	57,963	59,702	61,494
M/Q	98%	48%	223%	99%	290%	102%	34%

p/ preliminary data only for January-July 2000.
Source: SAGAR (2000).

The Mexican government established that the rights for the import-quota would be assigned through a public bid auction, which is open to the participation of physical and legal persons (individuals and firms) established in Mexico that fill the requirements in the bid announcement. The allocation is awarded to the minimum price bidder. The auction, which is held annually, is subject to specific regulations for tariffs and quotas, under the "Law of Foreign Trade".

Under an agreement with the World Trade Organization (WTO), Mexico agreed to annually reduce its initial non-NAFTA tariff of 139 % for beans, starting on January 1995 and up to 2004. This implies that at the end of the period, the tariff will be reduced to a level of 126%. Mexico has also signed agreements to reduce the tariffs on bean imports with other countries, including Costa Rica (1994), Bolivia (1995), Chile (1998) and Nicaragua (1998). The agreement with Costa Rica provides for gradually reducing tariffs on beans imported into Mexico over a fifteen-year period, starting from a tariff of 135.3% in 1995 to a tariff of 0% in 2009. Costa Rica will also reduce import tariffs to 0%, starting from an initial 55% tariff.

A similar agreement was made with Bolivia, under which Mexico will gradually reduce tariffs on beans imported into Mexico over a fifteen-year period, from an initial 133.4% in 1995 to 0% by 2009. Under the agreement with Chile, beans imported from Chile face a tariff of 0%. However, to import to Mexico, the importer must first obtain an import license. In the case of Nicaragua, the agreement grants a tariff-exempt quota of 4,000 Mt for beans imported into Mexico from April to August every year, with a 3% increase per year in the quota. However, imports from Nicaragua above the quota are assessed a tariff, which starting from an initial 127% will be phased out over a ten-year period.

4.1.4 Farm Credit

Public credit is administered through BANRURAL, a first floor development bank that provides loans and other bank services to farmers. During the period 1990-1999, BANRURAL assigned 68% of its total credit for short-term loans, 22% to long-term loans and 10% for other purposes (pledge loans). In 1990-1999, dry beans represented the second largest area receiving short-term loans. On average, 258,000 ha of beans were planted with BANRURAL credit during that period. About 15% of BANRURAL's total loans supported bean production (Table 4.4).

Table 4.4 Area Planted with BANRURAL Credit 1990-2000, Mexico.

Year	Thousands of hectares		Percentage of total area
	Total area	Bean area	
1990	1,951	275	14%
1991	1,236	193	16%
1992	1,198	123	10%
1993	1,045	82	8%
1994	1,129	92	8%
1995	1,251	249	20%
1996	1,851	376	20%
1997	2,178	343	16%
1998	2,115	450	21%
1999	2,105	323	15%
2000 p/	1,846	328	18%
Mean	1,628	258	16%

p/ preliminary data for 2000 subject to final revision.
Source: SAGAR (2000).

From 1990 to 1993, the total crop area covered by credit from BANURAL showed a decreasing trend—falling to 1,045,000 ha in 1993. After 1993, the total crop area trended upward through 2000. The bean area with credit basically followed the same pattern, ranging from a minimum of 82,000 ha in 1993 to a maximum of 450,000 ha in 1998.

Considering that the area planted to beans in 1990-2000 averaged 2.2 million hectares and the area that received credit averaged 258,000 ha, the share of the area receiving official credit represented only 11.7% of total bean area.

4.1.5 Crop Insurance

Beans have been one of the crops with the largest participation in the crop insurance program. In 1990-1999, the bean area protected with crop insurance was on average 180,000 ha, while the total area was 1,072,000. The share of beans in the total area with crop insurance averaged 17% (Table 4.5), which is larger than the share of beans in total planted area (10.6%).

Table 4.5 Bean Area Protected with Crop Insurance 1990-2000, Mexico.

Year	Thousands of hectares		Percentage of total area
	Total area	Bean area	
1990	1,226	239	19%
1991	624	38	6%
1992	870	46	5%
1993	912	72	8%
1994	1,050	78	7%
1995	915	96	10%
1996	1,146	215	19%
1997	1,218	191	16%
1998	1,358	263	19%
1999	1,123	350	31%
2000 p/	1,350	393	29%
Mean	1,072	180	17%

p/ preliminary data for 2000 subject to final revision.
Source: SAGAR (2000).

However, considering that the area planted to beans in 1990-2000 was on average 2.2 million hectares, the share of the area protected with crop insurance to grow beans represented only 8.2% of total bean area. In the early 1990s, both the total and the bean area with crop insurance decreased and reached a minimum in 1991. From 1992 to 2000, they both increase to reach a maximum for the total and bean area in 1998 and 2000, respectively.

Given that approximately 1.9 out of 2.2 million ha planted to beans are grown under rainfed conditions and that rainfall is highly variable from year-to-year, bean farmers face considerable risk. Consequently crop insurance plays a key role in supporting bean farmers. For this reason, the government has made an effort to increase the bean hectares covered by crop insurance, as well as the percentage of the total bean area covered. As a result, in 2000 the bean hectares covered by the insurance increased to 393,000 ha and the percentage of covered area, as a percentage of the total bean area (2.2 million ha), increased to 17.8%.

4.2 Research, Technical Assistance, and Seed Production

4.2.1 Research and Technology Transfer

Mexico's Agricultural Research and Technology Transfer Program (ARTTP), a component of the Alliance for the Countryside umbrella program, is intended to increase productivity by providing access of farmers to new technologies and by promoting agricultural research, diffusion, and technical assistance. The program is administrated by the "Fundaciones Produce" (Produce Foundations), which are state-level associations whose members are the leaders of farmer organizations. At the national level, they are associated under the "Coordinadora Nacional de Fundaciones Produce" (COFUPRO) (National Coordination for Produce Foundations) for the purpose of establishing a national strategy and to share experiences regarding how to strengthen agricultural research accelerate technology transfer.

According to the government regulations, the federal and state governments should allocate seven percent of the resources that they allocated to the Alliance for the Countryside program in each state to ARTTP. The regulations also recommend that at least 50 percent of those resources be allocated to projects and activities implemented by the INIFAP (the national institute for agricultural research), subject to the process of approval designed by each Produce Foundation (SAGARPA[10] 2001a).

ARTTP target agricultural producers and their economic organizations, and other agents in the agricultural and rural sector requiring specific projects or research activities, validation, and transfer of technology. The federal and state governments will provide support (equally matched) for research projects, and events of validation, demonstration, diffusion, and specialized training, and also for administration expenditures, equipment, and infrastructure for projects and events.

To receive resources from ARTTP, farmers and agents must submit an application to the Produce Foundations in their state. The Produce Foundations should inform the applicants in writing whether or not their application was approved (see Appendix E).

4.2.2 The National Research Institute for Forestry, Livestock, and Agriculture

Agricultural research in Mexico officially began in 1907, with the establishment of the Central Agricultural Experiment Station of San Jacinto D.F. In the 1930s, the

[10] The acronym of SAGAR for the Secretariat of Agriculture was changed to SAGARPA in 2001.

government created the Department of Experimental Stations under the Secretariat of Agriculture, which became the Agricultural Research Institute (IIA) in 1940.

In 1943, an agreement between the Secretariat of Agriculture and the Rockefeller Foundation created the Special Studies Office (OEE), dedicated exclusively to conducting research basic crops. In 1961, the challenge of providing food to a continuously increasing population led the Mexican government to create the Agricultural Research National Institute (INIA).

In 1985, this institute was renamed the "Instituto Nacional de Investigaciones Forestales, Agricolas y Pecuarias" (INIFAP) (National Research Institute for Forestry, Livestock, and Agriculture).

INIFAP has a mandate to implement projects and programs that:

"generate technologies that are necessary for increasing forest, agricultural, and livestock productivity and production in the country considering the interests, requirements, and socioeconomic conditions of producers, in such a way that the increased production may be able to meet the food and nutritional needs of an increasing population, the requirements of the domestic industry, and generate surplus for exporting, contributing to improve the well-being of peasants and population in general" (SAGARPA 2002).

INIFAP's strategy for achieving its objective includes the following:

- Development of domestic research capacity.
- Recognition and use of farmers' empirical knowledge.
- Rational exploitation of genetic materials.
- Realization of joint research.
- Exchange of materials and information.
- Validation of research results.
- Diffusion of research results.

Appendix F includes an explanation of these activities.

4.2.3 Technical Assistance Program

As part of Mexico's programs for agricultural development, implemented under the Alliance for the Countryside umbrella program, a technical assistance program named "Programa Elemental de Asistencia Tecnica" (PEAT) (Basic Program of Technical Assistance) was established with the following objectives (SAGARPA 2002):

- Promote the application of technologies by supporting eligible farmers to hire and pay for technical assistance services from independent contractors in all the stages of the productive process, including production planning, implementation of appropriate technological activities, preservation of the physical environment, acquisition and application of technological inputs, harvesting, storing, marketing, and the promotion of farmers' organizations.
- Diffuse technologies validated by research and teaching institutions, including the advances of innovative farmers, in order to accelerate farmers' adoption of technologies to reduce production risks, and increase yields and financial returns.
- Guarantee the quality of technical assistance and training by applying the norms and regulations for the authorization and registration of professionals, so that they are able to provide the services to programs coordinated by the SAGAR with the registration of the "Registro Federal de Tramites Empresariales (Entrepreneurial Procedures Federal Register).

The federal and state government will allocate resources to PEAT that can be used to provide the following types of financial support (SAGARPA 2001a):

- Up to 5% of PEAT budget for training farmers.
- Up to 10% for consulting, studies, and projects.

- Up to to 4% for promoting the formation of Professional Services Enterprises and Development Agencies.
- Up to 4% for operation expenditures.
- Up to 10% for the formulation of a Management Program for Training Professionals, and a monitoring system for the network of technical assistance.
- The remainder will be allocated to pay for professional technical assistance services provided by the technicians individually or through development agencies.
- Federal support for all purposes will not exceed 75%, and the rest will be covered by state governments.

Appendix G describes the requirements for eligibility.

4.2.4 The National Service for Seed Inspection and Certification

The "Servicio Nacional de Inspeccion y Certificacion de Semilla" (SNICS) (National Service for Seed Inspection and Certification), an organization of the Secretariat of Agriculture, is in charge of controlling and supervising the fulfillment of the legal regulations regarding seeds and plant varieties. The Mexican government has established the following three fundamental activities for the SNICS (SAGARPA 2002):

- Verify and certify the origin and the quality of the seeds.
- Provide legal protection to the rights of those who generate improved plant varieties.
- Coordinate actions regarding the use of genetic materials for food and agriculture.

Other important activities of the SNICS include promoting soil preservation, sustainable agriculture, and genetic diversity in crops of economic interest. Therefore, the activities in educational centers and government organizations related to phytogenetic resources are coordinated by the SNICS.

Technological advances in agriculture have generated many improved varieties. Certification implies the inspection of the origin of the seeds and verifying that improved varieties were produced under the established strict standards. Only seed that meets the requirements of high genetic quality, physiologic, physical and phytosanitary are certified by SNICS. In that way, SNICS ensures that certified seed acquired by farmers is of high yielding varieties.

The generation of improved varieties requires expensive resources. Therefore, to promote agricultural research and technology transfer, the "Ley Federal de Variedades Vegetales" (Vegetable Varieties Federal Law) was established to protect the rights of breeders. Breeders and organizations can obtain legal protection and secure the right to payment of royalties from those multiplying the variety. SNICS is in charge of the legal procedure for securing the breeder's patent and verifying that the improved varieties are different, uniform, and stable. The requirements to apply for a breeder's patent are included in Appendix H.

4.2.5 The National Producer of Seeds

Productora Nacional de Semillas (PRONASE) (National Producer of Seeds), an organization of the federal government, was created by the "Law of Production, Certification, and Trade of Seeds" in 1960. The institutional purpose of the PRONASE is to promote the production and utilization of certified seeds. The methods of genetic maintenance and technical management by which the seed is produced and marketed by the PRONASE ensure that its seed have high levels of genetic, physical, physiological, and phytosanitary quality.

The general objectives of the PRONASE are (SAGARPA 2002):

- To contribute to agricultural development and national food self-sufficiency by enhancing the production and utilization of certified seed of improved plant varieties that will allow farmers to increase their production and productivity.
- To be a profitable organization that through the best quality, prices, services and edge-technology increases its market share in certified seed market.

Since 1996 the PRONASE has participated in the Alliance for the Countryside, providing certified seed to the Kilo per Kilo program. PRONASE is charged with meeting the needs of all of the country's different agroecological conditions. Therefore, PRONASE multiplies seed of a wide range of crops (*e.g.*, maize, beans, oats, sorghum, wheat) and multiplies a diversity of hybrids and varieties that are adapted to different agroecological conditions. In addition, it multiplies a broad diversity of vegetable species and varieties that are suitable for mild, hot, cold, and extreme weather. In order to provide good service, PRONASE has licensed seed dealers throughout the country at which farmers can purchase the seeds.

PRONASE is required to meet the quality standards established by the SNICS. Quality control includes supervision of the stages of production, storage, preservation, and services to dealers. At the national level, at all of its agroindustrial plants, PRONASE has laboratories equipped for testing the seeds, according to the methods established by international organizations like the International Seed Testing Association (ISTA) and the Association of Official Seed Analysts (AOSA). PRONASE also provide external seed analysis and preservation services to dealers and farmers.

Most of PRONASE's certified seed are bred by scientists at INIFAP and other research centers in the country. PRONASE is in charge of multiplying the seed from small quantities to the commercial levels. To ensure quality, reproducing seed in the higher categories (basic and registered) is carried out directly in PRONASE's plots. To ensure a high level of genetic quality, the basic seed is subjected to a process of genetic maintenance. The seed obtained through this process is used to produce registered seed, under strict supervision by PRONASE's specialized technicians.

Registered seed is used to produce certified seed through contracts with individual farmers. According to the contract, PRONASE should offer farmers:

- Production credit, up to harvest.
- Technical supervision from specialized technicians.
- An economic incentive and purchase guarantee, if the seed meets the quality standards established by the quality control department of the PRONASE and those of the SNICS.

Seed that meets the quality standards is delivered to PRONASE's plants for cleaning, classification, and chemical treatment. This preparation process guarantees the physical, physiological, phytosanitary, and genetic quality that is required for certified seed. After SNICS verifies that the seed meets the expected quality standards, it provides labels of certification that must be attached to the seed sacks, which is a guarantee to farmers that the seed is of high quality.

4.3 Seed Distribution in the North of Mexico

4.3.1 National Program for Seed Distribution

In 1996, as component of the Alliance for the Countryside umbrella program, the Mexican government started a seed distribution program known as the Kilo per Kilo program. The objective of the program was defined as:

"Promoting the technological change and the shift to more productive crops under both rainfed and irrigated conditions through the substitution of certified seed of improved varieties for traditional varieties, and promoting the introduction of new species that can take advantage of the different agricultural regions in the country (SAGARPA 2001a)".

The program targets ejidatarios (small common property), small private farmers, and farmers' associations in areas recommended by studies carried out by INIFAP.

The program distributes seed of maize, beans, rice, oats, sorghum, amaranth, safflower, sunflower, canola, groundnuts, triticale and chickpeas, as well as other crops—intended to shift production into more productive crops—approved by the Directorate General of Agriculture (DGA).

Under the current (2000) program's regulations, a federal subsidy covers up to 45% of the difference between the price of the improved seed and the price of commercial grain. In addition, the state governments are allowed to cover up to 55% of the price difference. The prices of the commercial grain that is used to determine farmers' contribution to the program is formally published by the "Comite Tecnico del Fideicomiso" (Technical Committee of the Trust), based on the date when the seed is delivered to farmers. Computation of these prices is supported by information on market prices generated by the "Distritos de Desarrollo Rural" (Districts of Rural Development) and by other government organizations in charge of keeping records of commodity prices.

According to the regulations, a farmer may receive support for a maximum of five hectares. The amount of the federal subsidy is based on the quantity of seed per hectare that is recommended in the technological package. The support is provided per crop season. The number of years a farmer can receive the subsidy is determined by the Technical Committee of the Trust.

In order to participate in Kilo per Kilo, farmers must meet the following requirements:

- Fill out an application for the desired type of improved seed.
- Demonstrate they are agricultural producer by showing written proof from the county administration or from their farmers' organization.
- Submit a letter of commitment to make the necessary investments and follow the complementary practices required by the program.
- Comply with the phytosanitary campaigns in the region and participate in the technical assistance programs.
- Specify in the application the crop area (maximum of five hectares) that is located in a micro-region with the potential for the use of improved varieties where usually improved varieties have not been adopted before, or is located in a region where a shift of production into more productive crops is promoted.

The regulations also require that the program distributes certified seed. The varieties and planting densities should be the ones recommended in the technological packages validated by SAGAR and published in the "Boletin de Variedades Recomendadas" (Recommended Varieties Bulletin), as well as those that have been validated by the INIFAP and meet the "Lineamientos de Evaluacion" (Evaluation Standards) for the recommendation of varieties.

In exceptional cases, the Directorate General of Agriculture can approve the utilization of noncertified seed. In such cases, the state delegation of SAGAR should ask to the "Servicio Nacional de Inspeccion y Certificacion de Semillas" (SNICS) (National Service of Seed Inspection and Certification) to perform of germination, purity, and sanitation tests in order to ensure that the seed meet the required standards.

4.3.2 Seed Distribution in Chihuahua

In Chihuahua 1,252,000 hectares are cultivated (64% under rainfed conditions and 36% irrigated) by approximately 25,000 farmers in the state—although this number is decreasing due to migration. The main rainfed crops are beans, maize, oats, sorghum, wheat, and sunflower. During 1900-2000, the harvested dry bean area under rainfed conditions averaged 149,411 ha, with an average production of 70,729 Mt and an average yield of 473 kg/ha. The harvested area averaged 79% of the planted area, due to erratic weather conditions. The value of production averaged MX$ 209.9 million and the average producer price was MX$ 2.97 per kilo (INEGI 1992-2001).

During 1996-2000, the Kilo per Kilo program distributed 899 Mt of bean seed to 6,968 farmers, who planted 30,296 ha (Table 4.6). The annual area planted to improved varieties averaged 3.1% of the total bean area. The planted area averaged 4.3 ha per farmer and each farmer received an average of 129 kg of seed (30 kg per hectare). The quantity of seed distributed increased from 1996 to 1998, but decreased from 1998 to 2000, depending on the annual budget assigned to the Kilo per Kilo program. The number of beneficiaries and the area planted to MVs varied with the amount of seed distributed. The total investment of SAGAR in the program during 1996-2000 was MX$ 10,644,000 and the cost of the seed averaged MX$ 11.85 per kilo (SAGARPA 2001b).

Table 4.6 Statistics of the Kilo per Kilo Program for Beans in Chihuahua 1996-2000, Mexico.

Item	1996	1997	1998	1999	2000
Bean seed (Mt)	120	272	339	102	65.5
Beneficiaries (farmers)	818	1,993	2,501	1,179	477
Area (hectares)	4,308	8,885	11,302	3,632	2,171
Investment (000 MX$)	1,200	2,720	4,273	1,534	917
Quantity of seed (kg/ha)	27.8	30.6	29.9	28.1	30.1

Source: SAGAR (2001a).

In 1996, the Kilo per Kilo program distributed 120 Mt of certified seed of the variety Pinto Villa in the state of Chihuahua. In 1997, the program distributed a total of 272 Mt of improved bean seed. Pinto Villa accounted for 96% of the seed distributed and Pinto Americano accounted for 4% of the total (Table 4.7). Two categories of seed were distributed: certified seed and non-certified seed. In the case of Pinto Villa, 64% was certified seed and 36% was non-certified. In the case of Pinto Americano, 69% was certified seed and 31% non-certified.

Table 4.7 Bean Seed Distribution in Chihuahua through the Kilo per Kilo Program 1997, Mexico.

Variety	Quantity (kg)	Category	Area (ha)
Pinto Villa	154,385	Certified	5,042
Pinto Villa	84,700	Non-certified	2,766
P. Americano	22,800	Certified	745
P. Americano	10,161	Non-certified	332
Total	272,046	N.A.	8,885

Source: SAGAR (2001a).

In 1997, the program distributed 272 Mt of improved bean seed, which was planted on 8,885 ha. SAGAR estimated that due to the distribution of improved seed via the Kilo per Kilo program, bean yields of participants farming under rainfed conditions increased from 0.51 to 0.68 Mt/ha (33.3%) and their production increased from 4,089 to 5,488 Mt (34%), compared to non-participants (SAGAR-Chihuahua 1998).

In 1998, the program distributed a 339 Mt of improved bean seed. Pinto Villa accounted for 82% of the seed distributed and the varieties pinto Bill Z and Pinto Americano accounted for 18% of the total (Table 4.8). Both certified seed and non-certified seed were distributed. In the case of Pinto Villa, 80% was certified seed and 20% was non-certified seed. In the case of Bill Z and Pinto Americano, all of the seed was certified. The average price was MX$ 15.46 per kilo for certified seed and MX$ 5.70 for non-certified seed.

Table 4.8 Bean Seed Distribution in Chihuahua through the Kilo per Kilo Program 1998, Mexico.

Variety	Quantity (kg)	Category	Area (ha)
Pinto Villa	211,900	Certified	7,063
Pinto Villa	65,150	Non-certified	2,172
Bill Z	35,000	Certified	1,167
P. Americano	27,000	Certified	900
Total	339,050	N.A.	11,302

Source: SAGAR (2001a).

In 1998, total investment in the Kilo per Kilo program for dry beans was MX$ 4,273,000. By purchasing the seed, farmers covered 38.5% (MX$ 1,644,392) of the total cost and the government covered the remaining 61.5% (MX$ 2,629,216). The budget assigned to diffusion activities was $ 415,710 (9.7% of total), and the price farmers paid for improved seed averaged MX$ 4.85 per kilo. SAGAR estimated (SAGARPA 2001b) that participants yields increased by 32% and the increase in annual income per farmer averaged MX$ 1,087. The increase in the value of production was estimated at MX$ 2,719,300 and the increase in bean production at 565 Mt.

In 1999, the Program distributed 102 Mt of improved bean seed. Pinto Mestizo accounted for 97% of the seed distributed and Pinto Villa accounted for 3% of the total (Table 4.9). In both cases, all the seed distributed was certified seed. The cost for the government of the certified seed averaged MX$ 15.00 per kilo. The price of commercial grain of dry beans (about MX$ 3.40/kg) served as reference to determine the price the farmers had to pay for the certified seed. The subsidy of the program covered the difference between these two prices; therefore, the subsidy averaged MX$ 11.60/kg.

Table 4.9 Bean Seed Distribution in Chihuahua through the Kilo per Kilo Program 1999, Mexico.

Variety	Quantity (kg)	Category	Area (ha)
Pinto Mestizo	99,249	Certified	3,524
Pinto Villa	3,034	Certified	108
Total	102,283	N.A.	3,632

Source: SAGAR (2001a).

In 2000, the Program distributed 65.5 Mt of improved bean seed. Pinto Mestizo accounted for 75.7% of the seed distributed, Negro Altiplano 19.9%, and Pinto Villa 4.4% of the total (Table 4.10). In all cases, the seed distributed was certified seed. The average price for the certified seed was MX$ 14.00 per kilo (7% lower than in 1999). The price of commercial grain of dry beans was MX$ 5.00/kg. Thus, the subsidy averaged MX$ 9.00/kg.

Table 4.10 Bean Seed Distribution in Chihuahua through the Kilo per Kilo Program 2000, Mexico.

Variety	Quantity (kg)	Category	Area (ha)
Pinto Mestizo	49,554	Certified	1,643
Negro Altiplano	13,040	Certified	432
Pinto Villa	2,882	Certified	96
Total	65,476	N.A.	2,171

Source: SAGAR (2001a).

The amount of seed distributed in Chihuahua during 1996-2000 is summarized in Table 4.11. Certified seed accounted for 82 percent and non-certified seed accounted for 18 percent of the total. Together, Pinto Villa and Pinto Mestizo accounted for 88 percent of certified seed and other varieties for 12 percent. Pinto Villa also accounted for 94 percent of the non-certified seed and other varieties for 6 percent. Pinto Villa and Pinto Mestizo accounted for 90 percent of the total seed distributed and other varieties for 10 percent.

Table 4.11 Bean Seed Distribution in Chihuahua through the Kilo per Kilo Program 1996-2000, Mexico.

Variety	Certified	(%)	Noncertified	(%)	Total	(%)
Pinto Villa	492,201	67%	149,850	94%	642,051	73%
Pinto Mestizo	148,803	21%	0	0%	148,803	17%
Pinto Americano	32,961	5%	10,161	6%	43,122	5%
Bill Z	35,000	5%	0	0%	35,000	4%
Negro Altiplano	13,040	2%	0	0%	13,040	1%
Total	722,005	100%	160,011	100%	882,016	100%

Source: SAGAR (2001a).

4.3.3 Seed Distribution in Durango

In Durango 642,000 hectares are cultivated (79% under rainfed conditions and 21% irrigated) by approximately 80,000 farmers—although this number is decreasing due to migration. The main rainfed crops are beans, maize, oats, and wheat. During 1990-2000, the harvested dry bean area under rainfed conditions averaged 235,497 ha, with an average production of 109,745 Mt and an average yield of 466 kg/ha. The harvested area averaged 85% of the planted area—due to erratic weather conditions. The value of production averaged MX$ 297.2 million and the average producer price was MX$ 2.71 per kilo (INEGI 1992-2001).

During 1996-2000, the Kilo per Kilo program distributed 6,270 Mt of bean seed to 40,534 farmers, who planted 196,061 ha (Table 4.12). The annual area planted to improved varieties averaged 14.1% of the total bean area. The planted area averaged 4.0 ha per farmer and each farmer received an average of 127 kg of seed (32 kg per hectare).

The quantity of seed distributed increased from 1996 to 1998, but decreased from 1998 to 2000, depending on the annual budget assigned to the Kilo per Kilo program. The number of beneficiaries and the area planted to improved varieties varied with the amount of seed distributed. The total investment of SAGAR in the program during 1996-2000 was MX$ 43,416,000 per year and the cost of the seed averaged MX$ 6.92 per kilo (SAGARPA 2001c).

Table 4.12 Statistics of the Kilo per Kilo Program for Beans in Durango 1996-2000, Mexico.

Item	1996	1997	1998	1999	2000
Bean seed (Mt)	479	1,511	2,290	1,353	637
Beneficiaries (farmers)	4,061	10,517	15,177	14,193	5,586
Area (hectares)	15,966	39,976	76,065	42,952	21,102
Investment (000 MX$)	1,521	5,241	15,388	14,533	6,733
Quantity of seed (kg/ha)	30.0	37.8	30.1	31.5	30.1

Source: SAGAR (2001b).

In 1996, the Program distributed 479 Mt of Pinto Villa (Table 4.13), of which 3% was certified and 97% was non-certified seed. The certified variety was Flor de Mayo and the non-certified variety was Pinto Villa.

Table 4.13 Bean Seed Distribution in Durango through the Kilo per Kilo Program 1996, Mexico.

Variety	Quantity (kg)	Category	Area (ha)
Flor de Mayo	15,000	Certified	500
Pinto Villa	464,000	Non-certified	15,466
Total	479,000	N.A.	15,966

Source: SAGAR (2001b).

In 1997, the Program distributed a total of 1,511 Mt of improved bean seed (Table 4.14), of which 17% was certified and 83% was non-certified seed. The certified varieties were Flor de Mayo and Pinto Villa; and the non-certified varieties were Flor de Mayo, Negro Jamapa, and Pinto Villa.

Table 4.14 Bean Seed Distribution in Durango through the Kilo per Kilo Program 1997, Mexico.

Variety	Quantity (kg)	Category	Area (ha)
Flor de Mayo	181,320	Non-certified	4,797
Flor de Mayo	120,880	Certified	3,198
Negro Jamapa	846,160	Non-certified	22,387
Pinto Villa	226,650	Non-certified	5,996
Pinto Villa	135,990	Certified	3,598
Total	1,511,000	N.A.	39,976

Source: SAGAR (2001b).

In 1998, the Program distributed a total of 2,290 Mt of improved bean seed (Table 4.15), of which 10% was certified and 90% was non-certified seed. The certified varieties were Pinto Villa, Negro Altiplano, Flor de Mayo, and Negro Sahuatoba; and the non-certified varieties were Pinto Nacional and Negro Criollo.

Table 4.15 Bean Seed Distribution in Durango through the Kilo per Kilo Program 1998, Mexico.

Variety	Quantity (kg)	Category	Area (ha)
Pinto Nacional	1,401,480	Non-certified	46,552
Negro Criollo	659,520	Non-certified	21,907
Pinto Villa	95,498	Certified	3,172
Negro Altiplano	20,518	Certified	682
Flor de Mayo	47,966	Certified	1,593
Negro Sahuatoba	65,018	Certified	2,160
Total	2,290,000	N.A.	76,065

Source: SAGAR (2001b).

In 1999, the Program distributed a total of 1,353 Mt of improved bean seed (Table 4.16), of which 37% was certified and 63% was non-certified seed. The certified varieties were Pinto Mestizo, Pinto Villa, Pinto Bayacora, Azufrado Namiquipa, and Negro Altiplano; and the non-certified seed varieties were Negro Queretaro and Pinto Nacional.

Table 4.16 Bean Seed Distribution in Durango through the Kilo per Kilo Program 1999, Mexico.

Variety	Quantity (kg)	Category	Area (ha)
Negro Queretaro	378,840	Non-certified	12,027
Pinto Nacional	473,550	Non-certified	15,033
Pinto Mestizo	136,175	Certified	4,323
Pinto Villa	232,226	Certified	7,372
Pinto Bayacora	84,047	Certified	2,668
A. Namiquipa	15,494	Certified	492
Negro Altiplano	32,669	Certified	1,037
Total	1,353,000	N.A.	42,952

Source: SAGAR (2001b).

In 2000, the Program in Durango distributed a total of 633 Mt of improved bean seed (Table 4.17), of which 58% was certified and 42% was non-certified seed. The certified varieties were Negro Altiplano, Negro Sahuatoba, Pinto Mestizo, and Pinto Bayacora; and the non-certified varieties were Negro Altiplano, Negro San Luis, and Pinto Mestizo.

Table 4.17 Bean Seed Distribution in Durango through the Kilo per Kilo Program 2000, Mexico.

Variety	Quantity (kg)	Category	Area (ha)
Negro Altiplano	23,478	Certified	778
Negro Altiplano	25,539	Non-certified	846
Negro San Luis	117,680	Non-certified	3,898
Negro Sahuatoba	24,365	Certified	807
Pinto Mestizo	273,360	Certified	9,056
Pinto Mestizo	124,320	Non-certified	4,118
Pinto Bayacora	48,258	Certified	1,599
Total	637,000	N.A.	21,102

Source: SAGAR (2001b).

In 2000, the total investment in the Kilo for Kilo program for beans was MX$ 6,733,000, of which 46% was provided by the federal government, 15% by the state government, and 39% by farmers. SAGAR estimated that the yield of participants increased an average of 44% and their increase in annual income averaged MX$ 1,465 per hectare (SAGARPA 2001c). The increase in the value of production was estimated at MX$ 30,924,830 and the increase in bean production at 5,521 Mt.

The amount of seed distributed in Durango during 1996-2000 is summarized in Table 4.18. Certified seed accounted for 22 percent and non-certified seed accounted for 78 percent of the total. Pinto Villa, Pinto Mestizo, Flor de Mayo and Pinto Bayacora accounted for 87 percent of certified seed and other varieties for 13 percent. Pinto

Nacional, Negro Criollo, Negro Jamapa, and Pinto Villa accounted for 93 percent of the non-certified seed and other varieties for 7 percent. Pinto Nacional, Negro Criollo, Pinto Villa and Negro Jamapa accounted 79 for percent of the total seed distributed and other varieties for 21 percent.

Table 4.18 Bean Seed Distribution in Durango through the Kilo per Kilo Program 1996-2000, Mexico.

Variety	Certified	(%)	Noncertified	(%)	Total	(%)
Pinto Villa	463,714	34%	690,650	14%	1,154,364	18%
Pinto Mestizo	409,535	30%	124,320	3%	533,855	9%
Flor de Mayo	183,846	13%	181,320	4%	365,166	6%
Pinto Bayacora	132,305	10%	0	0%	132,305	2%
Negro Sahuatoba	89,383	7%	0	0%	89,383	1%
Negro Altiplano	76,665	6%	25,539	1%	102,204	2%
Azuf. Namiquipa	15,494	1%	0	0%	15,494	0%
Negro Jamapa	0	0%	846,160	17%	846,160	13%
Pinto Nacional	0	0%	1,875,030	38%	1,875,030	30%
Negro Criollo	0	0%	1,156,040	24%	1,156,040	18%
Total	1,370,942	100%	4,899,059	100%	6,270,001	100%

Source: SAGAR (2001b).

4.3.4 Seed Distribution in Zacatecas

In Zacatecas 1,343,690 hectares are cultivated (90% under rainfed conditions and 10% irrigated) by approximately 46,000 farmers—although this number is decreasing due to migration. The main rainfed crops are beans, maize, and oats for fodder. During 1990-2000, the harvested dry bean area under rainfed conditions averaged 577,891 ha, with an average production of 262,160 Mt and an average yield of 454 kg/ha. The harvested area averaged 84% of planted area—due to erratic weather conditions. The value of production averaged MX$ 688.7 million and the average producer price was MX$ 2.63 per kilo (INEGI 1992-2001).

During 1996-2000, the Kilo per Kilo program distributed 4,908 Mt of bean seed to 79,707 farmers, who planted 158,168 ha (Table 4.19). The annual area planted to improved varieties averaged 4.6% of the total bean area. The planted area averaged 2.0 ha per farmer, and each farmer received an average of 62 kg of seed (31 kg per hectare). The quantity of seed distributed increased from 1996 to 1998, but decreased from 1998 to 2000, depending on the budget assigned to the Kilo per Kilo program in each year. The number of beneficiaries and the area planted to improved varieties varied with the amount of seed distributed. The total investment of SAGAR in the Program during 1996-2000 was MX$ 36,864,000 per year and the cost of the seed averaged MX$ 7.51 per kilo (SAGARPA 2001d).

Table 4.19 Statistics of the Kilo per Kilo Program for Beans in Zacatecas 1996-2000, Mexico.

Item	1996	1997	1998	1999	2000
Bean seed (Mt)	641	808	2,473	481	504
Beneficiaries	4,750	6,522	21,421	29,997	17,017
Area (hectares)	18,330	29,063	76,277	17,481	17,017
Investment (000 MX$)	3,785	4,844	14,511	6,907	6,817
Quantity of seed (kg/ha)	34.9	27.8	32.4	27.5	29.6

Source: SAGAR (2001c).

In 1996, the Program distributed 641 Mt of improved bean seed (Table 4.20), of which 4% was certified and 96% was non-certified seed. The certified varieties were Flor de Mayo and Pinto Americano; and the non-certified varieties were Manzano, Bayo Blanco, Pinto Nacional, Negro San Luis, and Pinto Villa.

Table 4.20 Bean Seed Distribution in Zacatecas through the Kilo per Kilo Program 1996, Mexico.

Variety	Quantity (kg)	Category	Area (ha)
Manzano	19,793	Non-certified	566
Flor de Mayo RMC	15,350	Certified	439
P. Americano	10,000	Certified	286
Bayo Blanco	8,000	Non-certified	229
Pinto Nacional	421,493	Non-certified	12,053
Negro San Luis	122,274	Non-certified	3,497
Pinto Villa	44,089	Non-certified	1,261
Total	640,970	N.A.	18,330

Source: SAGAR (2001c).

In 1997, the Program distributed 808 Mt of improved bean seed (Table 4.21), of which 14% was certified and 86% was non-certified seed. The certified varieties were Flor de Mayo RMC, Negro Zacatecas, and Pinto Villa; and the non-certified varieties were Pinto Nacional, Flor de Junio, and Negro San Luis.

Table 4.21 Bean Seed distribution in Zacatecas through the Kilo per Kilo Program 1997, Mexico.

Variety	Quantity (kg)	Category	Area (ha)
Flor de Mayo RMC	51,307	Certified	1,844
Flor de Junio	2,810	Non-certified	101
Pinto Nacional	539,530	Non-certified	19,394
Negro Zacatecas	2,475	Certified	89
Pinto Villa	56,113	Certified	2,017
Negro San Luis	156,287	Non-certified	5,618
Total	808,522	N.A.	29,063

Source: SAGAR (2001c).

SAGAR-Zacatecas (1997) estimated that the yields of program participants under rainfed conditions increased by 34 percent for farmers planting certified seed, and by 26 percent for farmers who planted non-certified seed. Considering that 3,950 ha were planted to certified seed and 25,113 ha to non-certified seed, the estimated increase in production is 5,991 Mt with a value of approximately MX$ 25 million.

In 1998, the Program distributed 2,473 Mt of improved bean seed (Table 4.22), of which 11% was certified and 89% was non-certified seed. The certified varieties were Flor de Mayo RMC, Negro Zacatecas, and Pinto Villa; and the non-certified varieties were Flor de Mayo, Pinto Nacional, Manzano, Flor de Junio, and Negro San Luis.

Table 4.22 Bean seed distribution in Zacatecas through the kilo per kilo program 1998, Mexico.

Variety	Quantity (kg)	Category	Area (ha)
Flor de Mayo RMC	261,785	Certified	8,073
Flor de Mayo	160,692	Non-certified	4,956
Pinto Nacional	1,749,347	Non-certified	53,947
Manzano	61,201	Non-certified	1,887
Flor de Junio	69,096	Non-certified	2,131
Negro Zacatecas	3,075	Certified	95
Pinto Villa	3,375	Certified	104
Negro San Luis	164,858	Non-certified	5,084
Total	2,473,429	N.A.	76,277

Source: SAGAR (2001c).

In 1999, the Program distributed 482 Mt of improved bean seed (Table 4.23), of which 48% was certified and 52% was non-certified seed. The certified varieties were Flor de Mayo RMC, Flor de Mayo UAZ[11], Flor de Junio UAZ'86, Bayo Zacatecas, Manzano, Pinto Villa, and Garbancillo Supremo; and the noncertified seed varieties were Negro San Luis and Pinto Nacional.

[11] UAZ is the acronym for Universidad Autonoma Zacatecas.

Table 4.23 Bean Seed Distribution in Zacatecas through the Kilo per Kilo Program 1999, Mexico.

Variety	Quantity (kg)	Category	Area (ha)
Flor de Mayo RMC	200,420	Certified	7,276
Flor Mayo UAZ	4,784	Certified	174
Flor de Junio UAZ'86	4,640	Certified	168
Negro San Luis	252,050	Non-certified	9,150
Bayo Zacatecas	3,800	Certified	138
Manzano	1,560	Certified	57
Pinto Villa	9,909	Certified	360
Pinto Nacional	1,075	Non-certified	39
Garbancillo S.	3,300	Certified	120
Total	481,538	N.A.	17,481

Source: SAGAR (2001c).

In 2000, the Program distributed 505 Mt of improved bean seed (Table 4.24), of which 62% was certified and 38% was non-certified seed. The certified varieties were Flor de Mayo Sol, Negro Zacatecas, Flor de Mayo RMC, and Bayo Durango; and the non-certified varieties distributed were Pinto Villa, and Negro San Luis.

Table 4.24 Bean Seed Distribution in Zacatecas through the Kilo per Kilo Program 2000, Mexico.

Variety	Quantity (kg)	Category	Area (ha)
Flor de Mayo Sol	170,620	Certified	5,755
Pinto Villa	147,950	Non-certified	4,991
Negro Zacatecas	147,950	Certified	4,458
Negro San Luis	41,250	Non-certified	1,391
Flor de Mayo RMC	10,500	Certified	354
Bayo Durango	2,000	Certified	67
Total	504,490	N.A.	17,017

Source: SAGAR (2001c).

In 2000, the total investment in the Kilo for Kilo program was MX$ 6,817,470, of which 46% was provided by the federal government and 54% by the state government. SAGAR estimated that the yield of program participants increased on averaged by 35%

and their increase in annual income averaged MX$ 685 per hectare (SAGARPA 2001d). The increase in the value of production was estimated at MX$ 11,661,885 and the increase in bean production at 2,748 Mt.

The amount of seed distributed in Zacatecas during 1996-2000 is summarized in Table 4.25. Certified seed accounted for 19 percent and non-certified seed accounted for 81 percent of the total. Flor de Mayo and Negro Zacatecas accounted for 91 percent of certified seed and other varieties for 9 percent. Pinto Nacional and Negro Criollo accounted for 87 percent of the non-certified seed and other varieties for 13 percent. Pinto Nacional, Flor de Mayo, and Negro Criollo accounted for 88 percent of the total seed distributed and other varieties for 12 percent.

Table 4.25 Bean Seed Distribution in Zacatecas through the Kilo per Kilo Program 1996-2000, Mexico.

Variety	Certified	(%)	Noncertified	(%)	Total	(%)
Flor de Mayo	714,766	75%	160,692	4%	875,458	18%
Negro Zacatecas	153,500	16%	0	0%	153,500	3%
Pinto Villa	69,397	7%	192,039	5%	261,436	5%
Pinto Americano	10,000	1%	0	0%	10,000	0%
Flor de Junio	4,640	0%	71,906	2%	76,546	2%
Bayo Durango	2,000	0%	0	0%	2,000	0%
Manzano	1,560	0%	80,994	2%	82,554	2%
Pinto Nacional	0	0%	2,711,445	68%	2,711,445	55%
Negro Criollo	0	0%	736,719	19%	736,719	15%
Bayo Blanco	0	0%	8,000	0%	8,000	0%
Bayo Zacatecas	0	0%	3,800	0%	3,800	0%
Garbancillo Sup.	0	0%	3,300	0%	3,300	0%
Total	955,863	100%	3,968,895	100%	4,924,758	100%

Source: SAGAR (2001c).

4.4 Summary of the Chapter

In the early 1990s, the process of price liberalization required the government to develop new strategies to support agricultural development. Therefore, during the decade of 1990s the Mexican government, via the Secretariat of Agriculture (SAGAR), started several new programs to support farmers and raise their standard of living. In 1994, the government started PROCAMPO, a fifteen-year cash transfer program to help farmers make the transition from a government-regulated to a market-driven agricultural sector. As a complement to PROCAMPO, in 1996 the Federal Government started "Alianza para el Campo" (Alliance for the Countryside), a broad strategy for promoting agricultural production and rural development. For bean farmers, one of the most relevant components of Alliance for the Countryside is the Kilo per Kilo program, which has the objective to increase yields by promoting the substitution of modern varieties for traditional varieties. Since its inception, Kilo per Kilo program has shown positive results, as indicated by increased adoption rates and yields. Until 1993, bean prices were determined mainly by the strong intervention of the government through guaranteed prices. This system operated via CONASUPO, a parastatal that purchased commodities from farmers. But starting in 1993, the government initiated important changes to reduce government intervention and allow prices to be determined according to a freer interaction of market supply and demand. However, under the new price policy of free prices, growing beans under rainfed conditions is not sustainable without the direct support of PROCAMPO. While Mexico has signed trade agreements with different countries, the most important agreement (for most of the products including dry beans) has been the North American Free Trade Agreement (NAFTA). Under the NAFTA, import quotas and tariffs for imports of beans from the U.S. and Canada into Mexico are being phased out over a fourteen-year period. By 2008, dry beans will be tariff-exempt and they will be imported freely. From 1994 to 1999 there was a significant increase in the amount of beans imported, mainly from the U.S. During 1990-2000, bean production was partially supported by rural credit and crop insurance. BANRURAL provided public credit to 11.7% of the total bean area and crop insurance covered 8.2% of total bean area.

Several government institutions have been created to increase agricultural productivity. The Agricultural Research and Technology Transfer Program, a component of Alliance for the Countryside, is oriented to increase productivity by providing farmers access to new technologies and by promoting agricultural research (mainly through INIFAP), diffusion, and technical assistance. INIFAP's (National Research Institute for Forestry, Livestock, and Agriculture) objective is to improve the standards of living of farmers and the population in general by generating technologies to increase agricultural production and productivity. Among other activities, INIFAP scientists have been generating improved varieties for the most important crops in Mexico, including beans. The "Basic Program of Technical Assistance" (PEAT), a component of the Alliance for the Countryside, promotes the use of technologies generated by research institutions and improve the quality of technical assistance services. The "National Service for Seed Inspection and Certification" (SNICS), an organization of SAGAR, is in charge of verifying and certifying the origin and the quality of the seeds generated by research, provide legal protection to the rights of those who generate improved plant varieties, and coordinate actions regarding the use of genetic materials for food and agriculture. The "National Producer of Seeds" (PRONASE), an organization of the federal government, promotes the production and utilization of certified seeds. PRONASE is in charge of multiplying the seed from small quantities to the commercial levels. Most of PRONASE's certified seed is bred by scientists at INIFAP and other research centers in the country. Since 1996 the PRONASE has participated in Alliance for the Countryside by providing certified seed to the Kilo per Kilo program, which distributes certified seed (but also noncertified seed) to farmers at a price equivalent to commercial grain for a maximum of five hectares. A federal subsidy covers up to 45% of the difference between the price of the improved seed and the price of commercial grain. In addition, the state governments are allowed to cover up to 55% of the price difference. This significant reduction in price makes improved seed very affordable to farmers.

During 1996-2000, the Kilo per Kilo program distributed 12,077 Mt of bean seed to 127,209 farmers, which planted 384,525 ha in Chihuahua, Durango and Zacatecas in northern Mexico. SAGAR estimated that average yields increased in the range from 26% to 44%. The quantity of seed distributed increased from 1996 to 1998, but decreased from 1998 to 2000, depending on the annual budget assigned to the Kilo per Kilo program. SAGAR's total investment of in the program during 1996-2000 was MX$ 90,924,000 and the cost of the seed averaged MX$ 7.53 per kilo.

Two categories of seed were distributed: certified seed (25% of the total) and non-certified seed (75%), although some varieties were distributed under both categories. The certified varieties were PintoVilla (34%), Flor de Mayo (29%), Pinto Mestizo (18%), and other (19%).

The non-certified varieties were Pinto Nacional (51%), Negro Criollo (21%), Pinto Villa (11%), and other (17%). Pinto Villa and Pinto Mestizo were distributed mainly in Durango and Chihuahua. Pinto Nacional and Flor de Mayo were distributed mainly in Zacatecas and Durango. The improved varieties Pinto Villa, Pinto Mestizo, and Flor de Mayo were generated by INIFAP.

CHAPTER 5. IMPROVED VARIETIES ADOPTION ANALYSIS

This chapter presents the analysis of the cross-sectional data obtained from the farmer surveys in Chihuahua, Durango, and Zacatecas. Sections one to four report descriptive statistics for the data collected from farmers. These sections also report hypothesis testing results, using t-test for two means, chi-square for counts or percents, and analysis of variance (ANOVA) for comparison of several means. Section five analyzes the relationship between adoption and participation in the seed distribution program, and reports the results of the econometric analysis for explaining the factors associated with the participation of farmers in the Kilo per Kilo program. Section six presents a summary of the chapter.

5.1 Characteristics of Farmers and Farms in Northern Mexico

5.1.1 Characteristics of the Farmers

For this analysis, the farmers were divided into two groups: non-adopters and adopters. Non-adopters are defined as those farmers planting only traditional varieties in Spring-Summer 2001. Adopters are defined as those farmers planting improved varieties[12], including some farmers who planted both improved and traditional varieties. In Durango, the number observations was 206; non-adopters were 88 (43%), and adopters were 118 (57%). In Chihuahua, the number of observations was 163; non-adopters were 27 (17%), and adopters were 136 (83%). In Zacatecas, the number of observations was 86; non-adopters were 33 (38%), and adopters were 53 (62%). The total number of observations was 455; adopters were 307 (67%), and non-adopters were 148 (33%).

[12] Improved bean varieties included Negro Sahuatoba, pinto Bill Z, Pinto Bayacora, Flor de Mayo M38, Negro Altiplano, Negro Zacatecas, Pinto Mestizo, and Pinto Villa.

Table 5.1 reports the mean and the standard deviation for age of the farmers (years), years of experience as a farmer, years of education, and the percentage of farmers who farm under private property versus common property (ejido tenure) rights.

Regarding the age of farmers, compared to non-adopters, adopters were younger in Durango (47 vs. 49 years) and Chihuahua (47 vs. 57 years), and same age in Zacatecas (51 years). The difference is statistically significant (5% level) only for Chihuahua.

Regarding years of experience, adopters have less experience in Durango (26 vs. 31 years), Chihuahua (22 vs. 31 years), and Zacatecas (25 vs. 29 years). The differences are statistically significant for Durango and Chihuahua.

Regarding years of schooling, adopters have attended school longer in Durango (7 vs. 6 years), Chihuahua (7 vs. 5 years), and Zacatecas (6 vs. 5 years). The difference is statistically significant only for Durango.

Table 5.1 Characteristics of Farmers in Durango, Chihuahua, and Zacatecas 2001, Mexico.

Category	Durango (n=206)		Chihuahua (n=163)		Zacatecas (n=86)	
	Mean	Std Dev	Mean	Std Dev	Mean	Std Dev
Age (years)			(*)			
Nonadopters	49.10	14.29	56.85	13.13	51.00	12.55
Adopters	47.30	14.65	46.94	10.82	51.08	11.61
Experience (years)	(*)		(*)			
Nonadopters	31.01	15.92	31.40	19.14	29.28	14.10
Adopters	26.47	14.96	21.72	12.78	24.52	12.22
Education (years)	(*)					
Nonadopters	6.06	3.42	5.26	3.85	4.90	2.94
Adopters	7.08	3.80	7.27	6.11	5.88	5.44
Owner (percent)						
Nonadopters	47%	N/A[a]	26%	N/A	22%	N/A
Adopters	45%	N/A	43%	N/A	25%	N/A

(*) Indicates differences at the 5% level of significance in the t-test.
a. N/A means not applicable.

Regarding the percentage of landowners, adopters account for a lower percentage of owners in Durango (45 vs. 47%) and a higher percentage in Chihuahua (43 vs. 26%) and Zacatecas (25 vs. 22%). However the differences are not statistically significant.

5.1.2 Characteristics of the Farms

Table 5.2 reports the mean and the standard deviation for farm size, bean area, improved variety area, and the percentage of farmers having good soil, based on their own perception.

Regarding farm size (ha), compared to non-adopters, adopters have smaller farms in Durango (31 vs. 38 ha) and larger farms in Chihuahua (39 vs. 31 ha) and Zacatecas (31 vs. 22 ha). However the differences are not statistically significant.

Regarding the bean area (ha), adopters farm a smaller bean area in Durango (27 vs. 35 ha) and Chihuahua (24 vs. 29 ha) but a larger bean area in Zacatecas (25 vs. 19 ha). However the differences are not statistically significant.

Table 5.2 Characteristics of Farms in Durango, Chihuahua, and Zacatecas 2001, Mexico.

Category	Durango (n=206)		Chihuahua (n=163)		Zacatecas (n=86)	
	Mean	Std Dev	Mean	Std Dev	Mean	Std Dev
Farm size (ha)						
Nonadopters	37.63	42.20	31.05	59.77	22.26	19.80
Adopters	30.64	32.08	39.02	57.93	30.78	38.36
Bean area (ha)						
Nonadopters	34.87	38.08	28.77	60.11	19.26	18.43
Adopters	27.03	28.47	23.57	33.27	24.77	35.89
IVs area (ha)						
Nonadopters	N/A	N/A	N/A	N/A	N/A	N/A
Adopters	15.17	17.42	14.49	15.67	11.30	16.41
Good soil (percent)						
Nonadopters	42%	N/A	26%	N/A	6%	N/A
Adopters	46%	N/A	38%	N/A	12%	N/A

(*) Indicates differences at the 5% level of significance in the chi-square or t-test.

Regarding the area planted to improved varieties (ha), adopters plant a larger area to improved varieties (IVs) in Durango (15 ha) than in Chihuahua (14 ha) and Zacatecas (11 ha).

Regarding the percentage of farmers judging to have good soil, adopters have a higher percentage in Durango (46 vs. 42%), Chihuahua (38 vs. 26%), and Zacatecas (12 vs. 6%). However the differences are not statistically significant.

5.1.3 Sources of Technical Information

For Durango, additional information was collected regarding the means by which the farmer learned about the existence of the new improved bean varieties (Table 5.3). Among adopters, their most important source of technical information was SAGAR (64%) *i.e.*, the Secretariat of Agriculture, followed by other farmers (57%), technicians (48%), INIFAP (40%), demonstration plots (40%), and brochures containing technical information (35%). Although almost all percentages are higher for adopters than for non-adopters, these differences are not statistically significant.

Table 5.3 Percentage of Farmers by Source of Information, Durango 2001, Mexico.

Source of Information	Nonadopters	Adopters
Radio/TV	15%	17%
Newspaper	9%	11%
Technical brochure	30%	35%
Other farmer	44%	57%
Demonstration plots	37%	40%
SAGAR	52%	64%
Insurance company	0%	1%
Bank	4%	3%
INIFAP	33%	40%
Technicians	38%	48%

(*) Indicates differences at the 5% level of significance in the chi-square test.

5.2 Crop Practices, Production Costs, and Capital

5.2.1 Crop Practices and Chemical Inputs

Table 5.4 shows the percentage of non-adopters and adopters who used soil preparation (plow and harrow), were able to obtain seed of the variety that they wanted to plant, their mean bean planting date, and their perception of the number of years with bad weather (out of ten).

In Durango, the same percentage (94%) of adopters and non-adopters plowed their fields, while a higher percentage of adopters in Chihuahua (90 vs. 85%) and Zacatecas (94 vs. 84%) plowed their fields. However, the differences are not statistically significant.

Table 5.4 Soil Preparation and Planting Date in Durango, Chihuahua, and Zacatecas 2001 Mexico.

Category	Durango (n=206)		Chihuahua (n=163)		Zacatecas (n=86)	
	Mean	Std Dev	Mean	Std Dev	Mean	Std Dev
Plow (percent)						
Nonadopters	94%	N/A	85%	N/A	84%	N/A
Adopters	94%	N/A	90%	N/A	94%	N/A
Harrow (percent)						
Nonadopters	99%	N/A	96%	N/A	84%	N/A
Adopters	98%	N/A	97%	N/A	85%	N/A
Got seed (percent)	(*)					
Nonadopters	79%	N/A	52%	N/A	19%	N/A
Adopters	57%	N/A	55%	N/A	31%	N/A
Planting date[a]						
Nonadopters	199.58	9.70	176.00	21.59	189.28	20.07
Adopters	200.84	12.73	180.93	17.53	187.65	20.16
Bad years (percent)						
Nonadopters	3.91	2.80	5.63	3.16	4.66	2.29
Adopters	4.60	2.62	5.68	2.40	6.29	3.01

(*) Indicates differences at the 5% level of significance in the chi-square test.
a. Days after January 1, 2001.

In Durango, a lower percentage of adopters (98 vs. 99%) harrowed their fields, whereas a higher percentage of adopters in Chihuahua (97 vs. 96%) and Zacatecas (85 vs. 84%) harrowed. However, the differences are not statistically significant.

In Durango, a lower percentage (57 vs. 79%) of adopters were able to get the seed they wanted, while a higher percentage of adopters in Chihuahua (55 vs. 52%) and Zacatecas (31 vs. 19%) were able to get the seed they wanted. However, the difference is statistically significant only for Durango.

In Durango, adopters and non-adopters reported the same average planting dates (Jul 19). In contrast, adopters planted later (Jun 30 vs. Jun 25) in Chihuahua and they planted earlier in Zacatecas (Jul 6 vs. Jul 8). However the differences are not statistically significant.

While in Durango and Zacatecas adopters perceived that drought had occurred more frequently in the past ten years (Durango 4.6 vs. 3.9 years; Zacatecas 6.3 vs. 4.7 years), both groups reported the same average in Chihuahua (5.7 years). However, the differences are not statistically significant.

Table 5.5 shows the percentage of adopters and non-adopters who applied fertilizer, did mechanical weeding (weeding 1 and weeding 2), handweeding, and applied insecticide.

In Durango (50 vs. 45%) and Chihuahua (88 vs. 85%), a higher percentage of adopters fertilized their bean crop, whereas in Zacatecas a lower percentage of adopters (67 vs. 91%) applied fertilizer. However, the difference is statistically significant only in Zacatecas.

Table 5.5 Cultural Practices and Chemical Inputs in Durango, Chihuahua, and Zacatecas 2001, Mexico.

Category	Durango (n=206)	Chihuahua (n=163)	Zacatecas (n=86)
	Mean	Mean	Mean
Fertilizer (percent)			(*)
Nonadopters	45%	85%	91%
Adopters	50%	88%	67%
Weeding 1 (percent)			
Nonadopters	100%	85%	97%
Adopters	99%	76%	88%
Handweed (percent)			
Nonadopters	94%	89%	91%
Adopters	88%	80%	73%
Weeding 2 (percent)			
Nonadopters	98%	78%	84%
Adopters	96%	68%	71%
Insecticide (percent)	(*)	(*)	
Nonadopters	2%	59%	22%
Adopters	10%	78%	21%

(*) Indicates differences at the 5% level of significance in the chi-square test.

While first weeding was done by a lower percentage of adopters in Durango (99 vs. 100%), Chihuahua (76 vs. 85%), and Zacatecas (88 vs. 97%), the differences are not statistically significant. Handweeding was carried out by a lower percentage of adopters in Durango (88 vs. 94%), Chihuahua (80 vs. 89%), and Zacatecas (73 vs. 91%), but the differences are not statistically significant. Second weeding was carried out by a lower percentage of adopters in Durango (96 vs. 98%), Chihuahua (68 vs. 78%), and Zacatecas (71 vs. 84%), but differences are not statistically significant.

Insecticide was applied by a higher percentage of adopters in Durango (2 vs. 10%) and Chihuahua (78 vs. 59%), but by a lower percentage of adopters in Zacatecas (21 vs. 22%). The differences are significant in Durango and Chihuahua.

5.2.2 Production Costs, Credit, and Equipment

Table 5.6 reports adopters' and non-adopters' average cost of production per hectare, the percentage of farmers who received credit, the average amount of credit, and the percentage of farmers who owned a tractor and a tied-ridger.

Table 5.6 Production Costs, Credit, and Equipment in Durango, Chihuahua, and Zacatecas 2001, Mexico,

Category	Durango (n=206)		Chihuahua (n=163)		Zacatecas (n=86)	
	Mean	Std Dev	Mean	Std Dev	Mean	Std Dev
Prod Cost (MX$/ha)						
Nonadopters	1,714	419	1,366	1,167	1,386	1,236
Adopters	1,634	357	1,608	1,064	1,480	1,189
Credit (percent)						
Nonadopters	28%	N/A	30%	N/A	31%	N/A
Adopters	34%	N/A	21%	N/A	21%	N/A
Amount (MX$/ha)						
Nonadopters	373	1,237	714	1,783	898	2,586
Adopters	314	669	574	2,334	1,255	5,757
Tractor (percent)			(*)			
Nonadopters	70%	N/A	59%	N/A	63%	N/A
Adopters	75%	N/A	82%	N/A	62%	N/A
Tied-ridger (percent)						
Nonadopters	34%	N/A	22%	N/A	13%	N/A
Adopters	46%	N/A	26%	N/A	15%	N/A

(*) Indicates differences at the 5% level of significance in the chi-square test.

In Durango, average production costs were lower for adopters (MX$ 1,634 vs. 1,714), but higher for adopters in Chihuahua (MX$ 1,609 vs. 1,366) and Zacatecas (MX$ 1,480 vs. 1,386). However, the differences are not statistically significant.

In Durango, a higher percentage of adopters received credit (34 vs. 28%), whereas a lower percentage of adopters received credit in Chihuahua (21 vs. 30%) and Zacatecas (21 vs. 31%). However, the differences are not statistically significant.

On average, adopters received less credit in Durango (MX$ 315 vs. 374) and Chihuahua (MX$574 vs. 714), but larger loans in Zacatecas (MX$ 1,255 vs. 898). However, the differences are not statistically significant.

Tractors were owned by a higher percentage of adopters in Durango (75 vs. 70%) and Chihuahua (82% vs. 59%), but a lower percentage in Zacatecas (62% vs. 63%). The difference was statistically significant only in Chihuahua.

A tied-ridger was owned by a higher percentage of adopters in Durango (46 vs. 34%), Chihuahua (26% vs. 22%), and Zacatecas (15% vs. 13%), but the differences are not statistically significant.

5.2.3 Family Labor and Hired Labor

Table 5.7 reports the amount of total labor available to adopters and non-adopters including family and hired labor to grow beans, the number of family members having off-farm employment, and the number of months per year that the farmer and his wife work in an off-farm employment.

Less family labor is used by adopters in Durango (2.6 vs. 3.2 persons), but more is used by adopters in Chihuahua (2.3 vs. 2 persons) and Zacatecas (2.6 vs. 2.2 persons). The difference is statistically significant only for Durango.

More hired labor is used by adopters in Durango (2.7 vs. 1.7 workers) and Zacatecas (2.1 vs. 1.5 workers), but the same amount is used by both groups in Chihuahua (0.89 workers). The difference is statistically significant only for Durango. In total, adopters used more labor—family plus hired labor—than non-adopters in the three states. However, differences are not statistically significant.

Table 5.7 Family Labor, Hired labor, and Off-farm Employment in Durango, Chihuahua, and Zacatecas 2001, Mexico.

Category	Durango (n=206)		Chihuahua (n=163)		Zacatecas (n=86)	
	Mean	Std Dev	Mean	Std Dev	Mean	Std Dev
Family labor (No.)	(*)					
Nonadopters	3.24	1.92	2.04	1.48	2.22	1.41
Adopters	2.62	1.69	2.31	1.57	2.60	1.82
Hired labor (No.)	(*)					
Nonadopters	1.78	2.58	0.89	1.80	1.56	3.47
Adopters	2.77	3.21	0.89	1.51	2.10	3.16
Total labor (No.)						
Nonadopters	5.02	3.19	2.93	2.43	3.78	3.61
Adopters	5.39	3.66	3.20	2.36	4.69	3.39
Off-farm emp. (No.)						
Nonadopters	0.82	1.11	2.44	3.95	1.25	1.74
Adopters	1.10	1.28	1.26	1.81	1.37	1.94
Farmer (months)						
Nonadopters	4.17	4.80	8.19	4.80	8.06	4.54
Adopters	5.03	5.55	7.52	4.27	6.42	4.13
Wife (months)	(*)				(*)	
Nonadopters	1.13	3.52	4.52	5.61	5.91	5.68
Adopters	3.00	5.03	3.84	4.99	2.69	4.27

(*) Indicates differences at the 5% level of significance in the t-test.

More family members have off-farm employment in Durango (1.1 vs. 0.8 persons) and Zacatecas (1.3 vs. 1.2 persons), but fewer adopters have off-farm employment in Chihuahua (1.2 vs. 2.4 persons). However, differences are not statistically significant.

Adopters worked more months in off-farm employment in Durango (5.0 vs. 4.1 months), but fewer months in Chihuahua (7.5 vs. 8.1 months) and Zacatecas (6.4 vs. 8.0 months). However, the differences are not statistically significant.

The wives of adopters worked more months in off-farm employment in Durango (3.0 vs. 1.1 months), but fewer months in Chihuahua (3.8 vs. 4.5 months) and Zacatecas

(2.6 vs. 5.9 months). The differences are statistically significant in Durango and Zacatecas.

5.3 Program Participation, Storage and Prices of Beans

5.3.1 Participation in Government Programs

The government's Kilo per Kilo seed distribution program is farmers' primary source of improved bean seed and PROCAMPO is a cash transfer program. Table 5.8 reports the percentage of adopters and non-adopters (2001) who participated in these programs and characteristics of their participation.

Of the sampled farmers, the highest percentage of adopters participating in the Kilo per Kilo program was in Durango (65%), followed by Zacatecas (45%) and Chihuahua (35%).

Table 5.8 Program Participation in Durango, Chihuahua, and Zacatecas 2001, Mexico.

Category	Durango (n=206)		Chihuahua (n=163)		Zacatecas (n=86)	
	Mean	Std Dev	Mean	Std Dev	Mean	Std Dev
Kilo per Kilo (%)						
Nonadopters	N/A	N/A	N/A	N/A	N/A	N/A
Adopters	65%	N/A	35%	N/A	45%	N/A
Bean seed (kg)						
Nonadopters	N/A	N/A	N/A	N/A	N/A	N/A
Adopters	150.03	225.89	44.44	112.30	30.69	50.75
Seed price (MX$/kg)						
Nonadopters	N/A	N/A	N/A	N/A	N/A	N/A
Adopters	4.84	0.96	4.90	1.02	4.87	1.79
PROCAMPO (%)						
Nonadopters	100%	N/A	92%	N/A	97%	N/A
Adopters	97%	N/A	99%	N/A	96%	N/A
PROCAMPO (has)			(*)			
Nonadopters	33.52	35.97	9.38	7.00	16.01	12.35
Adopters	28.17	29.94	26.10	41.46	24.91	36.96

(*) Indicates differences at the 5% level of significance in the t-test.

Participants in Durango received the largest amount of seed (150 kg), followed by farmers in Chihuahua (44.4 kg), and Zacatecas (30.7 kg).

In all states, farmers paid about about the same price for a kilo of seed (Durango, MX$ 4.84; Chihuahua, MX$4.90; and Zacatecas, MX$ 4.87).

While almost all adopters and non-adopters participated in PROCAMPO, a lower percentage of adopters in Durango (97 vs. 100%) and Zacatecas (96 vs. 97%) participated in PROCAMPO, and a higher percentage participated in Chihuahua (99 vs. 92%). However, these differences are not statistically significant.

In Durango adopters registered fewer hectares in PROCAMPO than non-adopters (28 vs. 33 ha), but they registered more hectares in Chihuahua (26 vs. 9 ha) and Zacatecas (25 vs. 16 ha). However, the differences are statistically significant only for Chihuahua.

5.3.2 Storage of Beans and Farm Location

Table 5.9 reports market-related characteristics of adopters and non-adopters. In Durango, adopters stored smaller quantities of beans (6 vs. 14 Mt), but they stored more beans in Chihuahua (9 vs. 3 Mt) and Zacatecas (5 vs. 3 Mt). These differences are statistically significant in Durango and Chihuahua.

Adopters stored their beans for a shorter time in Durango (2.1 vs. 2.2 months) and Chihuahua (2.0 vs. 2.3 months), but for a longer time in Zacatecas (2.44 vs. 2.40 Mt). However, these differences are not statistically significant.

Adopters' farms were farther from the city in Durango (29 vs. 21 km) and Zacatecas (32 vs. 26 km), but closer to the city in Chihuahua (29 vs. 32 km). The difference is statistically significant only for Durango.

Table 5.9 Storage and Farm Location in Durango, Chihuahua, and Zacatecas 2001, Mexico.

Category	Durango (n=206)		Chihuahua (n=163)		Zacatecas (n=86)	
	Mean	Std Dev	Mean	Std Dev	Mean	Std Dev
Quantity Stor. (Mt)	(*)		(*)			
Nonadopters	14.45	33.67	2.81	6.07	3.17	3.61
Adopters	6.36	13.27	8.98	15.24	5.45	9.06
Stor. Time (months)						
Nonadopters	2.25	2.59	2.35	3.46	2.40	3.58
Adopters	2.14	2.49	1.99	1.87	2.44	2.77
Farm distance (km)	(*)					
Nonadopters	21.15	14.81	31.78	35.46	26.06	19.63
Adopters	29.21	23.56	28.69	44.80	31.92	22.61
Travel time (min)						
Nonadopters	34.86	20.83	47.04	41.17	46.31	31.49
Adopters	37.95	17.77	34.77	31.06	51.44	31.19

(*) Indicates differences at the 5% level of significance in the t-test.

Adopters reported longer travel times to their primary market in Durango (38 vs. 35 min) and Zacatecas (51 vs. 46 min), but shorter travel times in Chihuahua (35 vs. 47 min). However, these differences are not statistically significant.

5.3.3 Selling Prices of Beans by Market Class

During the survey, data were collected about the prices at which the farmer sold their beans (by market class). Following the 2000 harvest, farmers in Chihuahua (n=191) received the highest average selling price—MX$ 5.18 per kg, with a standard deviation of MX$ 1.70/kg (Table 5.10). For purposes of comparison, beans were grouped into the market classes (light color, pinto, and black beans).

Table 5.10 Selling Prices of Beans by Market Class in Chihuahua Mexico, 2000.

Variety name	Market class[a]	Mean (MX$/kg)	N	Standard Deviation	Group[b]
1 Canario	L	7.00	2	1.41	a
2 Bayo	L	6.75	2	1.77	ab
3 Flor de Mayo	L	6.52	4	1.76	abc
4 Bill Z (*)	P	6.14	7	0.63	abcd
5 Pinto Mestizo (*)	P	5.36	25	1.10	bcd
6 Mantequilla	L	5.13	8	1.46	cd
7 Ojo de Cabra	P	4.99	20	1.38	cd
8 Pinto Villa (*)	P	4.86	100	1.01	d
9 Negro Criollo	B	4.83	3	2.02	d
10 Pinto Nacional	P	4.71	20	1.12	d
Total	N/A	5.18	191	1.70	N/A

(*) Improved bean varieties.
a. L=ligth, P=pinto, B=black.
b. Groups of means in homogenous subsets at the 0.05 level, ANOVA.

In general, farmers received the highest prices for light-colored beans [*e.g.*, Canario (MX$ 7.00), Bayo (MX$ 6.75), Flor de Mayo (MX$ 6.52), and Mantequilla (MX$ 5.13)]. They received an intermediate range of prices for pinto beans [*e.g.*, Bill Z (MX$ 6.14), Pinto Mestizo (MX$ 5.36), Ojo de Cabra (MX$ 4.99), Pinto Villa (MX$ 4.86), and Pinto Nacional (MX$ 4.71)]. Farmers received the lowest prices are for black beans [*e.g.*, Negro Criollo (MX$ 4.83)]. The analysis of variance (ANOVA) rejected the null hypothesis of equal means (p-value<0.00005). The multiple comparisons displayed in the last column of the table indicates that the mean difference is not significant among the varieties from one through four, from two through five, from three through seven, and from four through ten, but is significant between those varieties that do not belong to the same group (*e.g.*, variety one and variety eight).

Farmers in Durango (n=394) received an average selling price of MX$ 4.05 per kg, with a standard deviation of MX$ 1.20/kg (Table 5.11). For purposes of comparison, beans were grouped into the market classes (light color, pinto, and black beans).

Table 5.11 Selling Prices of Beans by Market Class in Durango Mexico, 2000.

Variety name	Market class[a]	Mean (MX$/kg)	N	Standard Deviation	Group[b]
1 Bayo	L	5.75	4	1.75	a
2 Flor de Mayo	L	4.73	35	0.96	b
3 Pinto Nacional	P	4.68	34	1.24	b
4 Canario	L	4.61	40	1.39	b
5 Pinto Mestizo (*)	P	4.42	38	1.20	b
6 Pinto Bayacora (*)	P	4.42	10	0.83	b
7 Pinto Villa (*)	P	4.01	120	1.03	bc
8 Negro Sahuatoba (*)	B	3.29	10	0.75	c
9 Negro Criollo	B	3.27	94	0.92	c
10 Negro Altiplano (*)	B	3.24	9	0.90	c
Total	N/A	4.05	394	1.20	N/A

(*) Improved bean varieties.
a. L=ligth, P=pinto, B=black.
b. Groups of means in homogenous subsets at the 0.05 level, ANOVA.

In general, farmers received the highest prices for light-colored beans [*e.g.*, Bayo (MX$ 5.75), Flor de Mayo (MX$ 4.73), and Canario (MX$ 4.61)]. They received an intermediate range of prices for pinto beans [*e.g.*, Pinto Nacional (MX$ 4.68), Pinto Bayacora (MX$ 4.42), Pinto Mestizo (MX$ 4.42), and Pinto Villa (MX$ 4.01)]. Farmers received the lowest prices for black beans [*e.g.*, Negro Sahuatoba (MX$ 3.29), Negro Criollo (MX$ 3.27), and Negro Altiplano (MX$ 3.24)]. The analysis of variance (ANOVA) rejected the null hypothesis of equal means (p-value<0.00005). The multiple comparisons displayed in the last column of the table indicates that the mean difference is not significant among the varieties from two through seven and from seven through ten, but is significant between the variety one and the varieties from two through ten, and between the varieties from two through six and the varieties from eight through ten (as variety seven belongs to groups b and c its mean is only significantly different from the first variety).

In Zacatecas (n=119), farmers received an average selling price of MX$ 3.86 per kg with a standard deviation of MX$ 1.33/kg (Table 5.12). For purposes of comparison, beans were grouped into the market classes (light color, pinto, and black beans).

Table 5.12 Selling Prices of Beans by Market Class in Zacatecas Mexico, 2000.

Variety name	Market class[a]	Mean (MX$/kg)	N	Standard Deviation	Group[b]
1 Flor de Junio	L	4.57	13	1.89	a
2 Flor de Mayo	L	4.43	20	1.63	a
3 Negro Zacatecas (*)	B	4.24	5	1.13	ab
4 Bayo	L	4.15	13	0.97	ab
5 Canario	L	3.88	4	0.75	ab
6 Pinto Nacional	P	3.76	8	1.08	ab
7 Negro Criollo	B	3.41	56	1.08	b
Total	N/A	3.86	119	1.33	N/A

(*) Improved bean varieties.
a. L=ligth, P=pinto, B=black.
b. Groups of means in homogenous subsets at the 0.05 level, ANOVA.

In general, farmers received the highest prices for light-colored beans [*e.g.*, Flor de Junio (MX$ 4.57), Flor de Mayo (MX$ 4.43), Bayo (MX$ 4.15), and Canario (MX$ 3.88)]. They received an intermediate range of prices for pinto beans [*e.g.*, Pinto Nacional (MX$ 3.76). Farmers received the lowest prices for black beans [*e.g.*, Negro Zacatecas (MX$ 4.24) and Negro Criollo (MX$ 3.41)]. The analysis of variance (ANOVA) rejected the null hypothesis of equal means (p-value=0.020). The multiple comparisons displayed in the last column of the table indicates that the mean difference is not significant among the varieties from one through six and from three through seven, but is significant between the first two varieties and the last variety because they are in different group (a and b).

As noted previously, the mean prices farmers received varied greatly from state-to-state (*e.g.*, Chihuahua, MX$ 5.18; Durango, MX$ 4.05; and Zacatecas, MX$ 3.86). Similarly, the prices that farmers received for specific varieties varied greatly across states. For example, the price of Pinto Villa—the most commonly market variety—averaged MX$ 4.86 in Chihuahua, MX$ 4.01 in Durango, whereas in Zacatecas Negro Criollo (MX$ 3.41) was the dominant variety.

5.4 Area Planted to Improved Varieties and Yields

5.4.1 Area Planted to Improved Varieties

The surveyed farmers reported planting several different bean varieties over the 1997-2001 period. In Chihuahua (Table 5.13), modern varieties accounted for 71 percent of the planted area (five-year mean). The most widely planted varieties (five-year mean) were Pinto Villa (56%), Pinto Mestizo (15%), Ojo de Cabra (9%), Pinto Nacional (8%), Mantequilla (7%), and other (5%). The varieties that accounted for an increasing share of planted area during the five-year period were Pinto Mestizo (+13.5 points), Mantequilla (+8 points), and other (+1 points). In contrast, the share of the area planted to Pinto Villa (-17 points), Ojo de Cabra (-5 points), and Pinto Nacional (-0.5 points) declined during the period. These data suggest that while MVs have maintained their dominant share of the planted area, farmers are gradually replacing Pinto Villa with Pinto Mestizo.

Table 5.13 Percentage of Area Planted by Variety in Chihuahua Mexico, 1997-2001.

Variety	1997	1998	1999	2000	2001	Mean	Change[a]
Pinto Villa (*)	65	63	58	46	48	56	-17.0
Pinto Mestizo (*)	6	11	13	25	19	15	+13.5
Ojo de Cabra	11	10	13	4	7	9	-5.0
Pinto Nacional	11	7	5	7	10	8	-0.5
Mantequilla	3	3	7	12	10	7	+8.0
Other	4	6	4	6	6	5	+1.0
Total	100	100	100	100	100	100	--
Total hectares	1,948	1,865	2,333	2,520	3,984	12,650	--
Observations	118	121	143	167	263	812	--

(*) Improved bean varieties.
a. Absolute change in 1997-98 mean, versus 2000-01 mean in percent points.

In Durango (Table 5.14), improved varieties accounted for 42 percent of the planted area (five-year mean). The most widely planted varieties (five-year mean) were Pinto Villa (38%), Negro Criollo (25%), Pinto Nacional (12%), Canario (11%), Pinto Mestizo (4%), and other (10%).

Table 5.14 Percentage of Area Planted by Variety in Durango Mexico, 1997-2001.

Variety	1997	1998	1999	2000	2001	Mean	Change[a]
Pinto Villa (*)	34	43	46	35	33	38	-4.5
Negro Criollo	15	23	31	32	26	25	+10.0
Pinto Nacional	25	12	7	5	9	12	-11.5
Canario	20	17	7	4	7	11	-13.0
Pinto Mestizo (*)	0	0	4	10	5	4	+7.5
Other	6	5	5	14	20	10	+11.5
Total	100	100	100	100	100	100	--
Total hectares	573	1,146	4,440	6,451	6,507	19,116	--
Observations	69	103	244	381	418	1,215	--

(*) Improved bean varieties.
a. Absolute change in 1997-98 mean, versus 2000-01 mean in percent points.

The varieties that accounted for an increasing share of planted area during the five-year period were Negro Criollo (+10 points), Pinto Mestizo (+7.5 points), and other

(+11.5 points). In contrast, the share of the area planted to Pinto Villa (-4.5 points), Pinto Nacional (-11.5 points), and Canario (-13 points) declined during the period. These data suggest that while MVs have maintained their dominant share of the planted area, farmers are gradually replacing Pinto Villa with Pinto Mestizo, and are increasing the area planted to Negro Criollo (a traditional variety).

In Zacatecas (Table 5.15), modern varieties accounted for only eight percent of the planted area (five-year mean). The most widely planted varieties (five-year mean) were Negro Criollo (56%), Flor de Mayo (12%), Bayo (10%), Negro Zacatecas (8%), Pinto Nacional (6%), and other (8%). The varieties that accounted for an increasing share of planted area during the five-year period were Flor de Mayo (+5.5 points), Pinto Nacional (+1 point), and other (+12.5 points). In contrast, the share of the area planted to Negro Criollo (-9.5 points), Negro Zacatecas (-5.5 points), and Bayo (-4 points) declined during the period. These data suggest that while Negro Criollo has maintained its dominant share of the planted area, farmers are gradually replacing Negro Criollo with Flor de Mayo.

Table 5.15 Percentage of Area Planted by Variety in Zacatecas Mexico, 1997-2001.

Variety	1997	1998	1999	2000	2001	Mean	Change[a]
Negro Criollo	65	53	65	48	51	56	-9.5
Flor de Mayo	7	14	6	14	18	12	+5.5
Bayo	10	16	5	7	11	10	-4.0
Negro Zac. (*)	10	9	11	4	4	8	-5.5
Pinto Nacional	5	4	10	7	4	6	+1.0
Other	3	4	3	20	12	8	+12.5
Total	100	100	100	100	100	100	--
Total hectares	523	517	1,139	899	2,138	5,215	--
Observations	43	42	67	71	156	379	--

(*) Improved bean varieties.
a. Absolute change in 1997-98 mean, versus 2000-01 mean in percent points.

5.4.2 Yields of Traditional and Improved Varieties

The surveyed farmers also reported their yields for each variety that they planted over the 1997-2001 period. The five-years of data for Chihuahua, Durango, and Zacatecas were grouped by variety and analyzed as a pooled data set in order to analyze the performance of each variety during the period, and the yields of traditional compared to improved varieties. Farmers' mean yield (N=2,153)[13], averaged 492 kg/ha (Table 5.16), with a standard deviation of 273 kg and a coefficient of variation (C.V.) of 55%.

Table 5.16 Descriptive Statistics for Bean Yields in Northern Mexico, 1997-2001.

Variety name	N	Mean (kg/ha)	Std Dev	C.V.	95% C.I. for Mean	
					Lower B.	Upper B.
Negro Sahuatoba (*)	24	221	143	65%	161	281
Flor de Junio	32	346	151	44%	291	400
Bill Z (*)	21	379	222	59%	277	480
Queretaro[a]	9	394	118	30%	303	485
Bayo Blanco	57	411	230	56%	350	472
Canario	165	414	215	52%	380	447
Flor de Mayo	99	440	237	54%	393	487
Pinto Nacional	203	443	251	57%	409	478
Negro Criollo	384	481	245	51%	456	506
Pinto Bayacora (*)	19	482	226	47%	373	591
Flor de Mayo M38 (*)	23	485	161	33%	415	554
FM Media Oreja	60	490	165	34%	447	533
Negro Altiplano (*)	14	491	391	80%	266	717
Negro Zacatecas (*)	20	500	178	36%	417	583
Pinto Mestizo (*)	156	533	327	61%	481	584
Pinto Villa (*)	726	535	282	53%	515	556
Ojo de Cabra	101	561	377	67%	486	635
Mantequilla	40	673	322	48%	570	776
Total	2,153	492	273	55%	481	504

(*) Improved bean varieties.
a. Also known as bayo Rio Grande.

[13] The sample size is larger than the number of farmers (N=210) because the data set includes data on yields for the last five years (1997-2001). Some farmers planted up to three varieties. However, given that data were collected on a recall basis, there were missing values for earlier years.

The 95% confidence interval for the mean has a lower bound of 481 and an upper bound of 504.

For the pinto and black market classes, the yields of improved and traditional varieties were compared using a t-test. The two improved pintos (Pinto Mestizo and Pinto Villa) when analyzed together to represent "improved pintos". Their weighted average yield (535 kg/ha) was significantly higher (p-value<0.00005) than Pinto Nacional (443 kg/ha), with a yield difference of 91.4 kg (20.6%).

In contrast, the two improved black varieties Negro Altiplano and Negro Zacatecas jointly had a weighted average yield (496 kg/ha) that was not significantly higher (p-value=0.727) than Negro Criollo (481 kg/ha). Furthermore, the improved light variety Flor de Mayo M38 had a yield (485 kg/ha) that was not significantly higher (p-value=0.388) than Flor de Mayo (440 kg/ha). The other improved varieties were not analyzed because they had not been widely adopted by the farmers (*e.g.*, Pinto Bayacora), their yield was lower than traditional varieties (*e.g.*, Negro Sahuatoba), or because they were not bred by INIFAP (*e.g.*, Bill Z).

These data suggest that while improved pintos have higher yields than traditional pintos, there is no evidence that improved varieties of other market classes (black and light-colored beans) have higher yields than their respective traditional variety.

5.4.3 Adopters' Perception of Improved Varieties Characteristics

The surveyed adopters were asked their perceptions regarding the advantages of improved varieties compared to traditional varieties (Table 5.17). Based on farmers' mean response across the total sample (Chihuahua, Durango, and Zacatecas), adopters perceived that the improved varieties have a better quality for consumption (67%), require less days to maturity (59%), have a better plant type (57%), have higher yields (54%), have a better market acceptance (51%), are more resistant to diseases (43%), are more pest resistant (42%), are more drought resistant (41%), are better frost evaders (31%) (*i.e.*, require fewer days to maturity), and have less threshing problems (29%). These data suggest that better consumption quality (which is related to market acceptance), fewer days to maturity (which is related to drought resistance), and higher yields (which is related to the type of plant) are the most salient characteristics that influenced farmers' decision to adopt improved varieties.

Table 5.17 Percentage of Adopters Considering Improved Better than Traditional Varieties, Mexico 2001.

Category	Durango (adopters=118)	Chihuahua (adopters=136)	Zacatecas (adopters=53)	Mean (n=307)
Yields of grain	52%	59%	51%	54%
Drought resistance	38%	46%	39%	41%
Days to maturity	77%	49%	52%	59%
Market acceptance	47%	59%	47%	51%
Consumption quality	59%	73%	69%	67%
Pest resistance	28%	43%	54%	42%
Frost evasion	24%	33%	36%	31%
Threshing problems	17%	42%	27%	29%
Diseases resistance	43%	40%	47%	43%
Type of plant	49%	66%	55%	57%

5.5 Econometric Analysis of Program Participation

As noted previously, the Kilo per Kilo seed distribution program is the driving force for promoting the adoption of improved bean varieties in northern Mexico. This section first summarizes the relationship between adoption and program participation, then describes the model and variables used for the econometric analysis, and finally presents the results of the analysis. The analysis is based in the cross-sectional data set for 2001, which was collected during the face-to-face survey in the state of Durango. The descriptive statistics of the data were previously presented in sections 5.1 to 5.4 of this chapter.

5.5.1 Adoption of IVs and Program Participation

Farmer adoption of improved bean varieties in northern Mexico is largely determined by the government's seed distribution program (Kilo per Kilo), because there are practically no other sources of improved bean varieties. The program mainly distributes varieties developed by the INIFAP and other research centers in the country. Given that beans are "self-pollinated" and farmers do not have to purchase new seed every year, improved bean varieties have the characteristics of a public good (*i.e.*, a good that once produced is available to all on a nonexclusive basis). With appropriate management, farmers can save and share or sell the seed to other farmers, without experiencing a significant reduction in yields from one year to the next. This leads to a lack of economic incentives, which explains why there is minimal private sector participation in research to generate improved bean varieties, bean seed production, and seed marketing—although some farmers make contracts with the government through PRONASE to produce certified seed for the Kilo per Kilo program.

Table 5.18 shows that program participation in 2001 explains adoption in 37% of the cases and that no-program participation explains no-adoption in 43% of the cases, totaling 80% of the cases. The remaining 20% of the cases are adopters who did not participate in the program in 2001. However, all of these farmers either save the seed they planted from the seed that they obtained through the program in a previous year or obtained the seed they planted in 2001 from another farmers who participated in the program—either in the year of the survey or in previous years.

Table 5.18 Program Participation and Adoption of Improved Varieties in Durango Mexico, 2001.

Program participation	Improved variety	No. of observations	Percentage
Yes	Yes	77	37%
Yes	No	0	0%
No	Yes	41	20%
No	No	88	43%
Total		206	100%

Source: Survey data.

Considering the crucial role that the program plays in the diffusion of improved bean varieties, the rest of this section focuses on explaining the factors determining the participation of farmers in the program.

5.5.2 The Model for the Econometric Analysis

For the econometric analysis of the participation of farmers in the seed distribution program, a binary dependent variable with yes or no response was regressed on several independent variables selected from the literature review. Given that the range of values of the dependent variable is clearly restricted, a limited dependent variable model was used for the analysis. Limited dependent variable models can be used for time series and panel data, but they are most often applied to cross-sectional data. The linear probability model (LPM), logit, and probit models are all appropriate for analyzing data where the dependent variable is binary. The LPM can be estimated by using Ordinary Least Squares (OLS) method and the estimates can be interpreted as the changes in the probability of success, given a one-unit increase in the corresponding explanatory variable. The disadvantages of the LPM are that it can produce predicted probabilities that are less than zero or greater than one, the conditional probabilities increase linearly with the values of the explanatory variables, and heteroskedasticity (Wooldridge 2000; Gujarati 1995; Amemiya 1984).

The two nonlinear limited dependent variable models—logit and probit—are usually estimated by maximum likelihood estimation (MLE). The MLE is consistent, asymptotically normal, and asymptotically efficient. Both logit and probit models guarantee that the estimated probabilities lie in the 0-1 interval and that they are nonlinearly related to the explanatory variables. The disadvantage of nonlinear limited dependent variable models is that the results are more difficult to interpret because the change in one independent variable does not affect the probability of success (y=1) in a linear way. Rather, the change in probability of success for a given change in one explanatory variable depends both on the change in the variable and on the values of all the other explanatory variables in the model (Wooldridge 2000; Greene 1997; Kennedy 1992; Gujarati 1995; Maddala 1983).

The probit model can be derived from an underlying latent variable model that satisfies the classical linear model assumptions (Wooldridge 2002). Let y^* be an unobserved, or latent, variable determined by

$$y^*=\mathbf{x}\beta+e,\ y=1[y^*>0],\ e\sim\text{Normal }(0,1) \tag{1}$$

where $\mathbf{x}$ is a 1xK vector with the first element equal to unity, and β is a Kx1 vector of parameters. The assumptions are that e is independent of $\mathbf{x}$ and that e has a standard normal distribution. Instead of observing y^*, the binary variable y is observed indicating only the sign of y^*. The indicator function $1[\cdot]$ takes on the value of one if the statement in brackets is true and zero otherwise (then y=1 if $y^*>0$ and y=0 if $y^*=0$). From (1) and the given assumptions, the response probability for y is

$$P(y=1|\mathbf{x})=P(y^*>0|\mathbf{x})=P[e>-\mathbf{x}\beta|\mathbf{x})=1-\Phi[-\mathbf{x}\beta]=\Phi(\mathbf{x}\beta) \quad (2)$$

where $\Phi(\cdot)$ is the standard normal cumulative distribution function.

Considering that the econometric analysis in this dissertation is based on a cross-sectional data set, that a binary response variable was used for analyzing program participation, and the advantages of a nonlinear limited dependent variable models, the probit model was selected as appropriate to analyze farmers participation in the Kilo per Kilo seed distribution program. The probit model was selected over the logit model because the probit model's assumption of normality of the error term is a common assumption in economics; whereas the logit model assumes a standard logistic distribution of the error term. However, both models give similar results that are difficult to distinguish statistically (Wooldridge 2000; Amemiya 1981).

5.5.3 Description of the Variables

To analyze the factors explaining the farmer participation in the Kilo per Kilo program, the binary dependent variable "program" was defined as equal to one if the farmer was participating in the seed distribution program in 2001 and zero otherwise. The explanatory variables selected for the probit model of program particiaption are described in Table 5.19.

The independent variable "age" measures the age of the farmer in discrete years. Older farmers may have more experience, greater access to resources, or better social status—all of which increase their opportunity to participate in the program (CIMMYT 1993). Therefore, the sign on this variable is expected to be positive.

The independent variable "bnsarea" measures the total area planted to beans in hectares. As the program is aimed mainly at small farmers, the sign on this variable is expected to be negative.

The independent variable "badyears" measures the number of dry years —out of the past ten years—according to the farmer's perception. Farmer's technology choices are based on their subjective probabilities (Feder *et al.* 1985). An increased expectation of drought may affect positively farmer's decision to plant improved varieties that are drought resistant and thereby motivate them to participate in the seed distribution program. Therefore, the sign on this variable is expected to be positive.

Table 5.19 Identification of Variables in the Probit Model for Program Participation in Durango, Mexico, 2001.

Variable description	Variable name	Measurement	Expected sign
Dependent variable			
Program participation	program	Participation in the seed distribution program	Participation: no=0, yes=1
Independent variables			
Age of the farmer	age	Age of the farmer in years	(+)
Area planted to beans	bnsarea	Total bean area in hectares	(–)
Weather conditions	badyears	Dry weather out of ten years	(+)
Fertilizer use	fertilizer	Fertilizer: no=0, yes=1	(+)
Insecticide use	pesticid	Insecticide: no=0, yes=1	(+)
Tied-ridger use	tiedrdgr	Tied-ridger: no=0, yes=1	(+)
Credit to grow beans	credit	Got credit: no=0, yes=1	(+)
Off-farm employment	offarme	Family members employed	(+)
Distance to nearest city	distankm	Distance in kilometers	(+)
Consumption quality	consqlty	IVs quality: same=0, better=1	(+)

The independent variable "fertiliz" equals one if the farmer applies fertilizer and zero otherwise. The independent variable "pesticid" equals one if farmer applies insecticide and zero otherwise. Farmers who use modern inputs—like fertilizer and insecticide—are more likely to adopt other modern technologies (Feder *et al.* 1985). Thus, they may be more likely to participate in the seed distribution program. Therefore, the sign on these two variables is expected to be positive. Given that fertilizer and insecticide use depends mainly on weather and environmental conditions, simultaneity[14] was not considered to be a potential problem.

The independent variable "tiedrdgr" equals one if the farmer owns a tied-ridger and zero otherwise. Farmers who own a tied-ridger may be more likely to adopt a new technology (CIMMYT 1993), because the program gives preference to enrolling farmers who use improved soil conservation practices. Therefore, the sign on this variable is expected to be positive.

The independent variable "credit" equals one if the farmer got credit to grow beans and zero otherwise. Program participation may be facilitated by credit, especially if participation requires complementary investments (CIMMYT 1993; Feder *et al.* 1885). Therefore, the sign on this variable is expected to be positive. Given that credit is not provided to buy the improved seed distributed by the program, simultaneity was not considered to be a potential problem.

The independent variable "offarme" employment measures the number of family members having an off-farm employment during the year. The program is directed mainly to support farmers in marginal areas where farmers may have more incentives to look for off-farm employment to reduce the risk of farming. Therefore, the sign on this variable is expected to be positive.

[14] Simultaneity means that at least one explanatory variable (*e.g.*, "fertiliz") in a multiple regression model is determined jointly with the dependent variable (*e.g.*, "program").

The independent variable "distankm" measures the distance in kilometers from the farm to the nearest city (*e.g.*, the county city). The program is aimed mainly at distributing seed in areas where the IVs have not been adopted before—which are farther from the cities. Therefore, the sign on this variable is expected to be positive.

The independent variable "consqlty" equals one if the farmer believes that improved varieties have better consumption quality than traditional varieties and zero otherwise. Perceiving a better quality for consumption of the improved varieties may have a positive effect in farmer's decision to participate in the seed distribution program. Therefore, the sign on this variable is expected to be positive. Given that consumption quality depends mainly on preferences in the market, simultaneity was not considered to be a potential problem.

5.5.4 Results of the Analysis

The probit model was estimated by the maximum likelihood estimation (MLE) method, using the econometric software package Stata 6.0. The results of regressing "program" on the set of the selected explanatory variables show that five variables have coefficients that are statistically significant at the 0.05 level (Table 5.20). The coefficient for "bnsarea" is negative, as expected, indicating that smaller farmers are more likely to participate in the program than larger farmers.

The coefficients for "badyears", "pesticid", "tiedrdgr", and "distankm" are positive, as expected, indicating that the farmer's perception of a higher percentage of dry years, the use of insecticide, tied-ridger ownership, and a greater distance from the farm to the city have a positive effect on program participation. The coefficients for the variables "age", "fertiliz", "credit", "offarme", and "consqlty" are positive, as expected, but they are not statistically significant at the 0.05 level.

Table 5.20 Estimates of the Probit Model for Participation in the Kilo per Kilo Program in Durango, Mexico 2001.

Variables	Coefficient	Std. Error	z-value	P>|z|
age	0.0025	0.0075	0.333	0.739
bnsarea	-0.0080*	0.0038	-2.080	0.038
badyears	0.1191*	0.0436	2.727	0.006
fertiliz	0.0977	0.2419	0.404	0.686
pesticid	0.8079*	0.3956	2.042	0.041
tiedrdgr	0.4833*	0.2280	2.120	0.034
credit	0.3799	0.2424	1.567	0.117
offarme	0.1523	0.1046	1.456	0.145
distankm	0.0269*	0.0063	4.246	0.000
consqlty	0.4277	0.2220	1.926	0.054
constant	-2.2140	0.5150	-4.299	0.000
N=184, LR $chi^2(10)$=50.23, Prob>chi^2<0.00005, Log likelihood=-95.542146, Pseudo R^2=0.2082				

* Significant at the 0.05 level.

As a measure of the goodness-of-fit of the regression, the value of the Pseudo R^2 is reported. The value of the Pseudo R^2 shows that the proportion of the total sample variation in the dependent variable explained by the regression, corrected for degrees of freedom, is 0.2082. To test the joint significance of the coefficients of the explanatory variables used in the regression, the p-value for the chi-squared test is also included in Table 5.20. The p-value shows that the overall level of significance for the regression is less than 0.00005, which implies that the regression is significant.

The skewness and kurtosis test for normality was applied on the residuals of the regression for "program" (pgmres) to evaluate the assumption of normality of the error term of the probit model and to verify that selecting probit over tobit model was an appropriate choice. The results of the test (Table 5.21) suggest that there is no problem with skweness (p-value=0.247) or with kurtosis (p-value=0.438). The result of the joint chi-square test (p-value=0.375) indicates that the null hypothesis of normality of the error term cannot be rejected.

Table 5.21 Skewness and Kurtosis Test for Normality for Residuals.

Variable	Pr(Skewness)	Pr(Kurtosis)	------- Joint -------	
			Adj. Chi-sq(2)	Pr(chi-sq)
Pgmres	0.247	0.438	1.96	0.375

Therefore the results of the probit model can be considered reliable. Even when the assumption of normality is not essential for estimation, rejecting the hypothesis of normality would raise concerns about the validity of hypothesis testing on the coefficients of the model, although the results of the individual and joint hypothesis tests are still valid asymptotically.

The results of the econometric analysis confirm that in northern Mexico the participation of farmers in the seed distribution program is associated mainly with farm size and location. Smaller farmers located in marginal areas are more likely to participate in the program, which is consistent with the objectives of the Kilo per Kilo program for the distribution of improved bean varieties.

5.6 Summary of the Chapter

This chapter presents the analysis of the cross-sectional data obtained from the farmer surveys in Chihuahua, Durango, and Zacatecas. For this analysis, the farmers were divided into two groups: non-adopters and adopters. Non-adopters are defined as those farmers planting only traditional varieties in Spring-Summer 2001. Adopters are defined as those farmers planting improved varieties, including some farmers who planted both improved and traditional varieties. For Durango (n=206), non-adopters were 43%, and adopters were 57%. For Chihuahua (n=163), non-adopters were 17%, and adopters were 83%. For Zacatecas (n=86), non-adopters were 38%, and adopters were 62%. In total (n=455), non-adopters were 33% and adopters were 67% in northern Mexico.

When comparing adopters vs. non-adopters, the statistical analysis indicates that there are few differences regarding age, experience, education, and land tenure. Adopters are significantly younger in Chihuahua and they have more years of education in Zacatecas. There are not significant differences between adopters and non-adopters for farm size, bean area, area planted to improved varieties, and soil quality. In Durango, the most important sources of technical information are SAGAR (64%), other farmer (57%), technicians (48%), INIFAP (40%), demonstration plots (40%), and technical brochures (35%). No significant differences were found between the two groups of farmers. Also few significant differences were found for soil preparation, planting dates, and cultural labors. Adopters use less fertilizer in Zacatecas and they use more insecticide in Chihuahua and Durango than non-adopters. There are no significant differences for production costs, credit, and tied-ridger ownership, but adopters have higher percentage of tractor ownership in Chihuahua. There are no significant differences for the number of family members having an off-farm employment, but adopters use less family labor and more hired labor than non-adopters in Durango.

Adopters' participation in the Kilo per Kilo program was 65% in Durango, 35% in Chihuahua, and 45% in Zacatecas. There were no differences for participation in PROCAMPO, which was almost 100%.

There are few significant differences for quantities and months of storage, and for farm location (distance to nearest city). Adopters stored smaller quantities of beans in Durango, but they stored more beans in Chihuahua. Adopters' farms are farther from the city in Durango, compared to non-adopters' farms. Differences in traveling time are not significant.

The analysis of selling price by market class shows that in general, light color beans have the highest prices, followed by pintos and that the lowest price are for black beans. However, there were few significant differences.

The percentage of area planted to improved varieties averaged 71% in Chihuahua (Pinto Villa 56% and Pinto Mestizo 15%), 42% in Durango (Pinto Villa 38% and Pinto Mestizo 4%), and 8% in Zacatecas (Negro Zacatecas).

The statistical analysis of the yields indicates that while improved pintos have higher yields than traditional pintos (20.6%), there is no evidence that improved varieties of other market classes (black and light-colored beans) have higher yields than their respective traditional variety.

The surveyed adopters were asked their perceptions regarding the advantages of improved varieties compared to traditional varieties. The analysis of the data indicates that better consumption quality, market acceptance, fewer days to maturity (which is related to drought resistance and frost evasion), and higher yields are the most salient characteristics that influenced farmers' decision to adopt improved varieties.

The descriptive statistics show that the Kilo per Kilo program is the driving force for the adoption of improved bean varieties in northern Mexico. Therefore, an econometric analysis of program participation was carried out to investigate the factors explaining the participation of farmers in the Kilo per Kilo program. A probit model, with the binary dependent variable "program" to indicate program participation, was estimated by the maximum likelihood method.

The results of regressing "program" on the set of the selected explanatory variables indicate that smaller farmers are more likely to participate in the program than larger farmers. The results also suggest that the farmer's perception of a higher percentage of dry years, the use of insecticide, tied-ridger ownership, and a greater distance from the farm to the city have a positive effect on program participation.

The results of the econometric analysis confirm that in northern Mexico the participation of farmers in the seed distribution program is associated mainly with farm size and location. Smaller farmers located in marginal areas are more likely to participate in the program, which is consistent with the objectives of the Kilo per Kilo program for the distribution of improved bean varieties.

CHAPTER 6. BEAN RESEARCH ECONOMIC ANALYSIS

The collaborative research agreement between the INIFAP and the Bean/Cowpea Collaborative Research Support Program (CRSP) was signed on June 1st, 1982, and in 1983 the collaborative breeding program was initiated. During the period 1990-2000, INIFAP has released several improved bean varieties for rainfed conditions, with the support of the B/C CRSP. For the purpose of the economic evaluation of bean research, the relevant improved varieties are Pinto Villa (released in 1990) and Pinto Mestizo (released in 1996). The statistical analysis of Chapter 5 indicates that in both Chihuahua and Durango, these two varieties have yields that were significantly higher than the traditional pinto market class variety Pinto Nacional. The other improved varieties described in Chapter 5 were not considered in the economic assessment because there is not enough evidence that yields are significantly higher than the traditional varieties in the same market class. Similarly, Zacatecas is not included in the analysis, since the two improved pintos do not account for a major share of the bean area. However, research and extension costs for other varieties and for Zacatecas are included because they are part of the total cost of generating and promoting the improved varieties.

The returns to research investment for improved bean varieties in the north of Mexico are evaluated using the economic surplus method, which is the most common approach for analyzing the welfare effects of agricultural research in a partial-equilibrium framework, *i.e.*, in a model where the focus is on a single agricultural market and treats most other economic variables as being exogenous in the analysis. According to Alston *et al.* (1998), for most purposes, the partial-equilibrium economic surplus model is the best available method to evaluate returns to research.

6.1 Data for the Analysis

6.1.1 Area, Production and Yields

Considering that the analysis is focused on the improved varieties Pinto Villa and Pinto Mestizo, only the data for the states of Chihuahua and Durango are used in the analysis. During the period 1990-2000, while the total area planted to dry beans under rainfed conditions in Chihuahua and Durango averaged 466,883 ha (CV=14%) (Table 6.1), the area harvested averaged 384,909 ha (CV=24%), which implies a loss of planted area of 18% per year. During this period, total production averaged 180,474 Mt (CV=47%) and yields averaged 449 kg/ha (CV=30%). The large year-to-year variations in area, the high percentage of losses in the planted area, high variability in total production and yields, and low yields are largely explained by low and variable rainfall.

Table 6.1 Area, Production, and Yields for Dry Beans under Rainfed Conditions in Chihuahua and Durango Mexico, 1990-2000.

Year	Planted Area (ha)	Harvested Area (ha)	Quantity (Mt)	Mean Yield (kg/ha)	Area Planted to IVs (ha)[a]
1990	497,819	466,923	185,268	397	--
1991	412,840	392,879	227,933	580	--
1992	324,721	214,841	53,752	250	24,630
1993	471,964	453,722	304,940	672	87,983
1994	497,482	403,293	170,126	422	181,120
1995	505,006	415,247	183,759	443	230,788
1996	524,269	503,383	336,097	668	241,682
1997	490,098	259,226	98,153	379	192,613
1998	537,834	435,090	174,732	402	219,276
1999	479,613	409,142	149,017	364	157,703
2000	394,064	280,249	101,438	362	154,754
Average	466,883	384,909	180,474	469	135,504

a. Pinto Villa and Pinto Mestizo represent 86% of the area planted to improved varieties according to the data collected from the surveys with farmers.

Source: INEGI (1992-2001).

Over the last thirty years (1970-2000), annual rainfall in Durango has averaged 459 mm per year (CV=30%) and 429 mm in Chihuahua (CV=33%) (CONAGUA 2002).

The last column in Table 6.1 presents the area planted to improved bean varieties (about 86% are pintos), which shows an increasing trend from 1992 to 1996 and a decreasing trend from 1996 to 2000. Data from SAGAR were used for area planted to improved varieties instead of survey data because they include all of the counties where beans are grown and to avoid an overestimation of the adoption rate by including data only from those counties where the seed distribution was more concentrated. Data from seed distribution via Kilo per Kilo were not used to avoid an underestimation of the adoption rate because the seed that is saved by the farmers and used in subsequent years is not included. Before the federal government's Kilo per Kilo program started in 1996, farmer adoption of improved varieties (1992-1995) is explained by the effort of the state governments to produce and promote Pinto Villa, which was released in 1990, through programs specifically designed to make the improved seed affordable to small farmers. In fact, those programs provided the background that led to the design of subsequent programs including the Alliance for the Countryside, and especially Kilo per Kilo.

Data collected from the survey were used to estimate the incremental yields. Results from Chapter 5 (section 5.4.2) indicate that while there is no evidence that improved bean varieties of black and light-colored market classes have higher yields than their respective traditional variety, the yields of improved pintos (Pinto Villa and Pinto Mestizo) are significantly higher than the traditional variety (Pinto Nacional). Based on the evidence provided by the statistical results (section 5.4.2), the estimate of a 20% yield increase for the improved pintos was used in the analysis. The effect on returns of a potential reduction in the incremental yield is addressed the sensitivity analysis.

6.1.2 Value of Production and Prices

During the period 1990-2000, the value of production in Durango and Chihuahua averaged MX$ 507 million (Table 6.2). However, the value of production varied greatly from year-to-year, due to changes in the quantity produced each year, ranging from a minimum for 1992 (MX$ 122.92 million) to a maximum in 1996 (MX$ 1,267.13 million). Grower real domestic price averaged MX$ 1,973 per Mt, showed a decreasing trend over time, and exhibited large annual fluctuations (CV=29%). Considering that price differences among varieties are not significant (Sec. 5.3) and that most of the area is planted to pinto beans (Sec. 5.4), the average domestic price was used for the financial analysis of the improved pintos.

Table 6.2 Value of Production, Grower Real Domestic Price (1994=100) for Beans in Chihuahua and Durango Mexico, and FOB price for U.S. Pinto Beans, 1990-2000.

Year	Production Value (thousand MX$)	Grower Real Domestic Price (MX$/Mt)	FOB for U.S. Pinto Beans (US$/cwt)	FOB for U.S. Pinto Beans (US$/Mt)
1990	315,272	2,831	36.83	811.23
1991	436,285	2,597	19.76	435.24
1992	122,920	2,684	19.46	428.63
1993	592,117	2,077	27.03	595.37
1994	277,652	1,632	29.02	639.21
1995	381,745	1,539	21.25	468.06
1996	1,267,131	2,078	28.68	631.72
1997	415,116	1,933	25.25	556.17
1998	882,134	1,990	26.31	579.52
1999	462,791	1,050	20.40	449.34
2000	425,469	1,295	19.69	433.70
Average	507,148	1,973	21.04	548.02

Source: INEGI (1992-2001) and ERS (2002b).

The FOB price for U.S. pinto beans required to compute the import parity price (IPP) —to be used in the economic analysis as the opportunity cost of producing beans domestically instead of importing them from the U.S.—is also included in Table 6.2. The FOB price is originally reported in U.S. dollars per hundredweight (cwt), and was converted into U.S. dollars per metric ton for the analysis.

6.1.3 INIFAP and B/C CRSP Research Costs

Research expenditures associated with developing improved bean varieties for Northern Mexico (under the agreement of the INIFAP with the Bean/Cowpea CRSP) started in 1983 (Table 6.3). After at least eight years of investing in research and development, several new varieties were released. For the purpose of the analysis, the relevant varieties are Pinto Villa (released in 1990) and Pinto Mestizo (released in 1996). INIFAP's expenditures in support of its bean research (1983-1996), totaled MX$ 14,151,998 (70% of total), while the B/C CRSP's expenditures totaled MX$ 5,926,378 (30% of total).

Table 6.3 Research Cost of Bean Research in Chihuahua, Durango, and Zacatecas Mexico 1983-2000.

Year	INIFAP (MX$)	B/C CRSP (MX$)	Year	INIFAP (MX$)	B/C CRSP (MX$)
1983	42,949	7,392	1992	1,206,557	475,242
1984	65,921	14,820	1993	1,304,440	476,657
1985	102,378	28,837	1994	1,395,331	648,220
1986	184,779	76,322	1995	1,672,000	1,025,422
1987	421,895	58,801	1996	2,520,000	1,171,822
1988	713,646	283,492	1997	268,800	122,417
1989	841,660	327,667	1998	375,250	140,121
1990	995,309	371,969	1999	429,750	151,373
1991	1,142,134	399,077	2000	469,200	146,727

Source: INIFAP (2000b) and CRSP (2002).

After the release of Pinto Mestizo in 1996, only 10% of the expenditures in the bean research program are included for both the INIFAP and B/C CRSP, which reflects an estimation of the costs required for seed multiplication and for maintaining the quality of the varieties.

6.1.4 Extension and Adoption Costs

During the period 1996-2000, government investments (SAGAR) in the Kilo per Kilo seed distribution program in Chihuahua, Durango, and Zacatecas increased from MX$ 6,506,000 in 1996 to MX$ 34,172,000 in 1998 and then decreased to MX$ 14,467,000 in 2000, totaling MX$ 90,924 (Table 6.4). The Kilo per Kilo budget basically depends on the availability of federal and the state governments resources, the agreements between the federation and the states, and the government's criteria for assigning the budgetary resources among the different sectors of the economy and between programs within the same sector (*i.e.*, according to the priorities established for PROCAMPO and for the components of Alliance for the Countryside). The budget for government programs is also affected by the political cycle of the presidency (Zedillo 1994-2000), which usually reflects low levels at the beginning and the end of the administration.

Table 6.4 Budget of the Kilo per Kilo Program in Northern Mexico, 1996-2000.

Year	Thousands of Mexican Pesos (MX$)					
	1996	1997	1998	1999	2000	Total
Chihuahua	1,200	2,720	4,273	1,534	917	10,644
Durango	1,521	5,241	15,388	14,533	6,733	43,416
Zacatecas	3,785	4,844	14,511	6,907	6,817	36,864
Total	6,506	12,805	34,172	22,974	14,467	90,924

Source: SAGAR (2001a, 2001b, 2001c).

Farm-level adoption costs are the increase in production costs of adopting a new technology, relative to the unimproved technology. In the case of improved bean varieties, the new technology involves only a change of variety, with negligible additional costs compared to other varieties because the price difference between the improved and the traditional seed is covered by the subsidy of the Kilo per Kilo program. Therefore, farm-level adoption costs assumed to be zero in the financial analysis, but in the economic analysis, the price subsidy for the improved seed is removed.

6.1.5 Consumer Price Index and Exchange Rate

To convert nominal prices and costs into real terms, the consumer price index (CPI) is commonly used. Table 6.5 shows that the CPI in Mexico increased considerably faster in the 1980s than in the 1990s. The nominal exchange rate (ER) to convert U.S. dollars into Mexican pesos is also included in the Table 6.5, which shows a continuous increase over the period—raising to more than three times higher in 2000 than in 1992 (when adoption started).

Table 6.5 Consumer Price Index and Exchange Rate in Mexico, 1983-2000.

Year	Consumer Price Index (1994=100)[a]	Exchange Rate (MX$/US$)	Year	Consumer Price Index (1994=100)	Exchange Rate (MX$/US$)
1983	1.60	0.1221	1992	85.20	3.0907
1984	2.70	0.1700	1993	93.50	3.0999
1985	4.30	0.2830	1994	100.00	4.2157
1986	8.00	0.6585	1995	135.00	6.6688
1987	18.50	1.5941	1996	181.40	7.6209
1988	39.60	2.2489	1997	218.80	7.9613
1989	47.50	2.4755	1998	253.70	9.1127
1990	60.10	2.8102	1999	295.80	9.8444
1991	73.70	3.0150	2000	323.83	9.5423

a. The base-year for official statistics on CPI in Mexico is currently 1994.
Source: INEGI (1996, 2001).

This rapid depreciation in the Mexican peso resulted from Mexico's decision in the early 1990s to adopt a floating exchange rate regime, allowing the ER to fluctuate freely in response to changing economic conditions.

6.2 Basis of the Economic Analysis

6.2.1 Supply and Demand Elasticities

According to Alston *et al.* (1998), while total research benefits are relatively insensitive to elasticities of supply and demand, elasticity assumptions (or estimates) are much more important in relation to the distribution of benefits. In particular, the more elastic supply is, relative to demand, the greater the consumer share of total research benefits (and smaller the producer share) and vice versa. Conclusions obtained using linear supply and demand functions with a parallel shift apply fairly generally, but in the case of a pivotal supply shift, whether producers benefit from research depends on the elasticity of demand—when demand is inelastic producers lose (*i.e.*, all of the benefits go to consumers). However, Oehmke and Crawford (2002) show that when using the Alston *et al.* (1998) approach, returns to research may be very sensitive to the supply elasticity parameter. In contrast, the returns calculated using the Akino-Hayami (1975) procedure are relatively invariant to the value of the supply elasticity. Thus, they recommend using the Alston *et al.* (1998) approach because of its conceptual and practical advantages, and to address the sensitivity of research returns to the supply parameter by investing greater efforts to obtain sound empirical estimates of the supply elasticity.

In this dissertation a value of 0.5 was assumed for the elasticity of supply. This value is within the range reported by other researchers [*e.g.*, 0.5 for beans by Mather (1999); 0.21-0.35 for agricultural production (Tsakok 1990)], and because most published elasticities of supply for agricultural products fall between 0.1 and 1.0 (Alston *et al.* 1998). Also, an absolute value of 0.5 was assumed for the elasticity of demand, based on the demand elasticity of 0.49 for pulses (beans included) and of 0.45 for coarse grains (*e.g.*, maize) reported by Tsakok (1990).

6.2.2 Supply and Demand Functional Forms

Linear supply-and-demand curves have been used in the majority of studies that estimate research benefits. With such curves, the elasticities change as quantity changes along the curve. When a parallel shift is assumed, the functional form is largely irrelevant. Thus, a linear model provides a good approximation—regardless of the true functional form of supply. The main alternative is to use constant elasticity curves that are typically combined with an assumption of pivotal shift, which is the most important consequence of the functional form choice. Empirically, the measures of total research benefits and their distribution between producers and consumers are quite insensitive to the choices of functional form. They are much more sensitive to the separate choices concerning the nature of the research-induced supply shift and elasticities (Norton *et al.* 1998).

According to Masters (1996), linear curves are an appropriate specification for many situations. Following the approaches of Norton *et al.* (1998) and Masters (1996), two of the most widely used approaches currently used for returns-to-research calculations, linear supply-and-demand curves are assumed in this dissertation. In addition, a pivotal supply shift is assumed as explained in the next section.

6.2.3 Research-Induced Supply Shift

The choice of the nature of the research-induced supply shift is crucially important in the analysis. In contrast, the choices of functional forms and elasticities are not very significant (Alston *et al.* 1998). When using a linear supply function, a parallel shift almost doubles the total research benefits—compared to a pivotal shift. When the supply shift is parallel, producers always benefit from research but, as mentioned before, with a pivotal shift producers benefit only when demand is elastic. When demand is inelastic, producers necessarily lose from a pivotal supply shift.

Considering that the yield increase resulting from the use of the improved bean varieties is proportionally the same for different levels of production, then the most reasonable assumption is that the supply shift must be proportional. Therefore, a pivotal (or proportional) research-induced supply shift was chosen for the computation of total research benefits. Furthermore the use of a pivotal shift will always generate conservative estimates of total economic benefits compared to a parallel shift, but in this case the use of parallel (nonproportional) research-induced supply is not the most appropriate choice.

6.2.4 The Logistic Adoption Curve

Much of the literature on diffusion assumes that the cumulative proportion of adoption follows a S-shaped curve in which there is slow initial growth in farmers adoption of the new technology, followed by a more rapid increase, and then slower adoption down as the cumulative proportion of adoption approaches its maximum (Griliches 1957; CIMMYT 1993). The most common function used to represent the curve is the logistic function given by $P=K/(1+e^{-\alpha-\beta t})$, where P = the percentage of area using the new technology at time t, K = the upper bound of adoption (the ceiling), α = a constant, related to the time when adoption begins, and β = a constant, related to the rate of adoption.

The equation can be transformed to $\ln(P/K-P)= \alpha+\beta t$, which makes it possible to directly estimate the parameters α and β by ordinary least squares (OLS) regression. The value of K can be estimated by plotting the data and choosing the level that appears to be the upper bound of adoption or by running the regression using different values of K and choosing the one that maximizes R-squared value. In this dissertation, a logistic curve was used to fit the actual data on adoption and to project future adoption levels for purposes of the economic evaluation.

6.2.5 Economic Surplus Formulas for a Closed Economy

This section presents the formulas for estimating the social gains from research in a closed economy model. The closed economy refers to a situation where the price of the commodity is determined inside the country of interest (Alston *et al.* 1998). The formulas and estimations of research benefits for the small open economy model, where the price is exogenous, are given in section 6.6.

Net economic benefits or net gains are estimated as NG=SG-R-E, where SG=social gains, R=research costs, and E=extension costs. Social gains for a parallel shift are estimated as $SG=KPQ\pm0.5KP\Delta Q$, where K=vertical supply shift, P=observed product price, Q=observed quantity produced, and ΔQ=quantity change. The second term is subtracted when data are observed after adoption (an *ex post* study) and added if adoption has not yet ocurred (*ex ante* study) (Masters 1996). For a pivotal shift, the first term is multiplied by 0.5, as shown below. The supply shift is estimated as $K=(J/\varepsilon)-C$, where J=proportional quantity increase, ε=elasticity of supply, and C=proportional cost increase. The proportional quantity increase is estimated as $J=(\Delta Y/Y)*A$ where Y=mean yield, ΔY=yield increase, and A=adoption rate expressed as proportion of the total area.

The proportional costs are estimated as $C=\Delta CA/YP$, where ΔC=adoption costs (additional costs of the new technology). The quantity change is estimated as $\Delta Q=(QK\varepsilon\eta)/(\varepsilon+\eta)$, where η=demand elasticity. Plugging ΔQ into $SG=KPQ\pm 0.5KP\Delta Q$ gives $SG=KPQ\pm[0.5PQK^2\varepsilon\eta/(\varepsilon+\eta)]$.

In the case of a pivotal supply shift, the formulas for change in total surplus (ΔTS), change in consumer surplus (ΔCS), and change in producer surplus (ΔPS), are estimated as: $\Delta TS=0.5KPQ(1+Z\eta)$ $\Delta CS=ZPQ(1+0.5Z\eta)$ $\Delta PS=\Delta TS-\Delta CS$ where $Z=K\varepsilon/(\varepsilon+\eta)$ is the reduction in price, relative to its initial value, due to the supply shift (Alston *et al.* 1998). Plugging Z into ΔTS gives $\Delta TS=0.5KPQ+[0.5PQK^2\varepsilon\eta/(\varepsilon+\eta)]$ for a pivotal shift, which can easily be compared with the formula shown above for a parallel shift. Multiplying the first term by 0.5 leads to a smaller total surplus for a pivotal shift. In this dissertation, the net economic benefits were computed by deducting the research and extension costs from the ΔTS (pivotal shift), where the second term was subtracted because the analysis is an *ex post* assessment.

6.2.6 Net Present Value and Rate of Return

There are several alternative methods to evaluate a stream of benefits and costs associated with a particular research program. Generally, they involve calculating summary statistics such as the internal rate of return or the net present value. The net present value (NPV) of a research program investment is calculated as the sum of the stream of past or future benefits (B_t) minus the costs (C_t) associated with the program, discounted at an appropriate rate (r) as follows:

$$\mathrm{NPV} = \sum_{t=1}^{n} \frac{(\mathrm{Bt} - \mathrm{Ct})}{(1 + \mathrm{r})^{\mathrm{t}}}$$

where: B_t=benefit in each year; C_t=cost in each year; n=number of years; t=1,2,..., n; and r=discount rate (most often the opportunity cost of capital or OCC).

The internal rate of return (IRR) is calculated as the discount rate at which the NPV is exactly zero.

$$\sum_{t=1}^{n} \frac{(\mathrm{Bt} - \mathrm{Ct})}{(1 + \mathrm{IRR})^{\mathrm{t}}} = 0$$

According to the NPV criterion, any program with a positive NPV is profitable. According to the IRR criterion, programs are profitable if the IRR is greater than the opportunity cost of funds. Typically, the results of the calculations for both the IRR and the NPV are reported to provide broader information for assessing the total returns to research (Alston *et al.* 1998; Gittinger 1982).

6.3 Financial Analysis

Financial analysis is done by using the observed market price—the price at which a good or service is actually exchanged for another good or service or for money (financial price). This section presents the results of the financial analysis using the economic surplus method. After analyzing the costs and benefit streams associated with the bean research program, the net present value and the internal rate of return are reported.

6.3.1 Financial Cost Stream

The financial cost stream (Table 6.6) includes the the expenditures of the Kilo per Kilo program (started in 1996), INIFAP's research cost, and the financial contributions of the B/C CRSP from 1983 when collaborative research started to 2000, ten years after Pinto Villa was released and four years after Pinto Mestizo was released.

Table 6.6 Total Research and Extension Real Costs in Northern Mexico, 1983-2000.

Year	Research Costs (1994 MX$)	Extension Costs (1994 MX$)	Year	Research Costs (1994 MX$)	Extension Costs (1994 MX$)
1983	3,146,302	--	1992	1,973,942	3,677,120
1984	2,990,406	--	1993	1,904,916	6,768,352
1985	3,051,497	--	1994	2,043,551	16,227,237
1986	3,263,764	--	1995	1,998,090	12,719,470
1987	2,598,360	--	1996	2,035,183	3,586,549
1988	2,518,027	--	1997	178,801	5,852,148
1989	2,461,741	--	1998	203,142	13,469,350
1990	2,275,006	--	1999	196,458	7,766,684
1991	2,091,196	--	2000	190,201	4,467,613

Source: Tables 6.3, 6.4, and 6.5.

The costs of the seed distribution programs for 1992-1995 in northern Mexico (before the Kilo per Kilo program started), were estimated by multiplying the number of hectares planted to improved varieties (Table 6.1) times the average cost per hectare (1996-2000). Total nominal costs were converted into real cost dividing them by the consumer price index (divided by 100).

6.3.2 Financial Benefit Stream

Table 6.7 shows the gross social gain and the net gain from research in real financial terms from 1983 to 2000 (base-year=1994). Social gain was computed by using the formulas and assumptions stated in section 6.2, regarding the elasticities and functional forms of supply and demand for *ex post* analysis with a pivotal research-induced supply shift. The incremental net gain was computed by subtracting the total real and extension costs from the social gain. In the first ten years, the benefit stream is negative because there was a period of eight years of research investment before the variety Pinto Villa was released in 1990, and it took two more years before adoption started and turned the stream to positive numbers.

Table 6.7 Social and Net Gains from Research in the North of Mexico, 1983-2000.

Year	Social Gain (1994 MX$)	Net Gain (1994 MX$)	Year	Social Gain (1994 MX$)	Net Gain (1994 MX$)
1983	0.00	-3,146,302	1992	2,172,032	-3,479,030
1984	0.00	-2,990,406	1993	23,170,976	14,497,708
1985	0.00	-3,051,497	1994	19,481,128	1,210,340
1986	0.00	-3,263,764	1995	24,664,446	9,946,886
1987	0.00	-2,598,360	1996	61,433,719	55,811,987
1988	0.00	-2,518,027	1997	14,326,600	8,295,651
1989	0.00	-2,461,741	1998	27,196,272	13,523,781
1990	0.00	-2,275,006	1999	9,950,534	1,987,392
1991	0.00	-2,091,196	2000	9,914,161	5,256,348

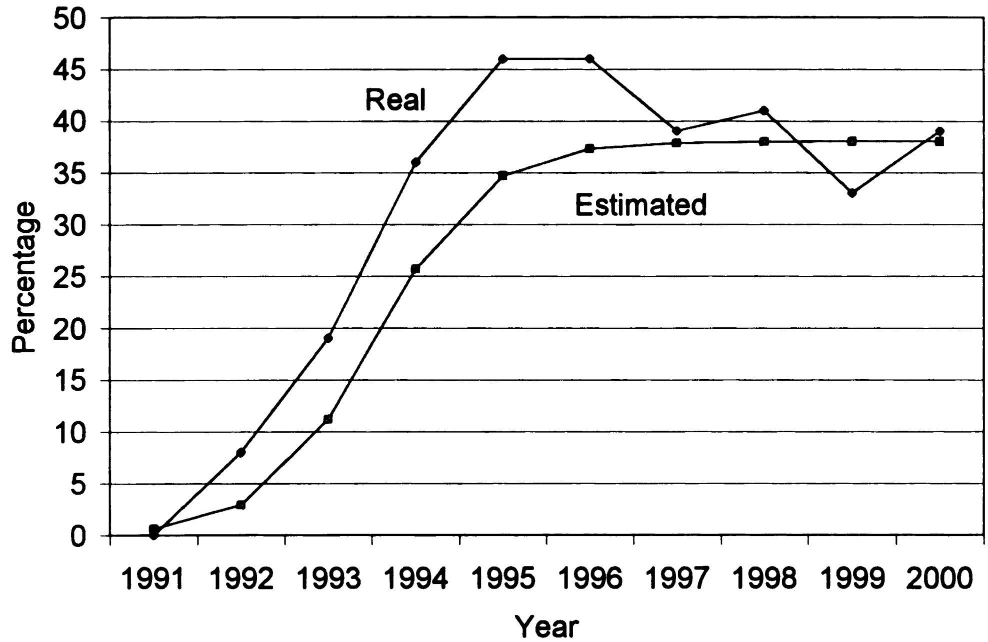
Source: Computed from data on Tables 6.1, 6.2, and 6.5.

6.3.3 Financial Rate of Return

The period from 1983 (when research started) to 2010 was considered as the appropriate period for evaluating the economic impact of the improved bean varieties. Because the collaborative research program began in 1983, this was selected as the first year to be included in the analysis. The selection of 2010 as the cut-off year allows for twenty years of evaluation after the first improved pinto bean variety (Pinto Villa) was released in 1990. For purposes of the evaluation, the costs and benefits streams were assumed to remain constant in real terms after 2000. The logistic curve used to fit the data on adoption rate (Figure 6.1) shows that the adoption of improved pintos seems to have reached the ceiling in a level of approximately 38%. The parameters for the curve (α=-5.70, β=1.61) were obtained from the transformed equation $\ln(P/K-P)= \alpha+\beta t$ by an

OLS regression using K=38. Therefore, it is reasonable to assume no further increases in the percentage of area using the improved pinto varieties. The possibility of changes in key elements of the costs and the benefits of bean research (*e.g.*, adoption rate decrease) is addressed in the sensitivity analysis.

Figure 6.1 Logistic Curve for Estimating the Rate of Adoption in Mexico, 1991-2000.



Source: Table 6.1 for “real”; “estimated” is based on logistic curve estimate.

The results from the financial analysis—using a pivotal shift—indicate that the net present value (NPV) of the investment in bean research is MX$ 17,681,052 (base-year=1994), when using a discount rate of 10%, which is the estimated cost of opportunity of capital (OCC) in agricultural activities in Mexico (FIRA 2001). The estimated internal rate of return (IRR) is 17.5%, which is almost twice as much the OCC. As mentioned before, according to the NPV criterion, any program with a positive NPV is considered to be profitable, and, according to the IRR criterion, a program is profitable if the IRR is greater than the opportunity cost of funds. Therefore, since the financial point of view, investing in generating and promoting the use of improved bean varieties in northern Mexico has been a profitable investment under both the NPV and the IRR criteria.

Regarding the distribution of the benefits (change in total surplus of MX$ 107,051,062), over the period 1992-2000[15] (*i.e.*, the period when the improved varieties were adopted), change in consumer surplus was MX$ 204,052,485, and the change in producer surplus was MX$ -97,001,423. These results indicate that all the benefits from the change in total surplus were captured by the consumers and that producers actually have a loss, as result of the demand being inelastic (η=0.5), because this implies that the percentage reduction in output price is larger than the percentage increase in the quantity demanded by consumers.

6.4 Economic Analysis

Economic analysis is done by using the economic values. If there are no market distortions, the financial price and the economic price are equal. However, if market distortions exist (*i.e.*, subsidies, tariffs), the economic price is estimated as the opportunity cost (shadow price). This section presents the results of the economic analysis using the economic surplus method. After analyzing the costs and benefits streams of bean research, the net present value and the internal rate of return are computed.

[15] This period is different from the period 1983-2010 used to estimate the NPV and IRR because the focus is on estimating the distribution of research benefits between consumers and producers.

6.4.1 Economic Cost Stream

The financial and economic analyses are complementary. However, while the financial analysis assesses the financial effects of an investment on individual participants, the economic analysis takes the point of view of the society. In the case of the cost stream, there was no need to adjust the research and extension costs for market distortions (*e.g.*, taxes, subsides, or exchange rate).

Therefore, the cost stream used for the economic analysis was the same as the cost stream for the financial analysis.

6.4.2 Economic Benefit Stream

In the case of the economic benefits streams (Table 6.8), two main adjustments were made. First, the subsidy for the price of the seed distributed through the Kilo per Kilo program was removed. Second, the import parity price (IPP) at the farm gate level, in real terms (base-year=1994), was used instead of the domestic price for pinto beans. There are some caveats regarding the use of the IPP to estimate the opportunity cost of producing beans domestically instead of importing: a) the analysis is based in the use of annual average prices for both domestic and IPP, which doesn't show the month-to month bean price fluctuation; b) the price of imported beans depends not only on the market class but also on the origin, the quantity and the season when beans are imported; and c) the beans imported, even if they are of the same market class (*i.e.*, pintos) may not exactly match the characteristics of the domestically-produced beans.

To compute the IPP at the farm gate level the FOB price for U.S. pinto beans (Table 6.2) was adjusted to approximate the CIF price (which includes freight and insurance charges to point of import) by using the FAO's standard conversion factor of

112 percent (FAO 2002b). Then, the estimated CIF price was converted into Mexican pesos by using the official exchange rate (Table 6.5), and finally adjusted by marketing and transportation costs to the bean production areas of Chihuahua and Durango to estimate the IPP at farm gate. The official exchange rate was not adjusted (*e.g.*, for overvaluation) because in the early 1990s Mexico adopted a floating exchange rate regime under which the exchange rate was allowed to fluctuate freely in response to changing economic conditions (Mankiw 1992). During the research phase (1983-1991), both the economic social gain and the incremental net gain are the same as in the financial analysis because the research cost stream are the same. After adoption started, both the economic social gain and the incremental net gain are higher than in the financial analysis because the higher price of imported beans (IPP) more than offsets the removal of the seed subsidy, which increases the cost of the improved seed.

Table 6.8 Social and Net Gains from Research in Northern Mexico, 1983-2000.

Year	Social Gain (1994 MX$)	Net Gain (1994 MX$)	Year	Social Gain (1994 MX$)	Net Gain (1994 MX$)
1983	0.00	-3,146,302	1992	761,966	-4,889,096
1984	0.00	-2,990,406	1993	22,138,552	13,465,284
1985	0.00	-3,051,497	1994	32,698,863	14,428,075
1986	0.00	-3,263,764	1995	37,535,593	22,818,033
1987	0.00	-2,598,360	1996	81,313,630	75,691,898
1988	0.00	-2,518,027	1997	14,067,838	8,036,888
1989	0.00	-2,461,741	1998	26,982,999	13,310,507
1990	0.00	-2,275,006	1999	13,897,187	5,934,045
1991	0.00	-2,091,196	2000	8,978,218	4,320,405

Source: Computed from data on Tables 6.1, 6.2, and 6.5.

6.4.3 Economic Rate of Return

As in the case of the financial analysis, the period from 1983 to 2010 was used for evaluating the economic impact of the improved bean varieties. The costs and benefits streams were assumed to remain constant in real terms after 2000. The possibility of changes in key elements of the costs and the benefits of bean research and extension is addressed in the sensitivity analysis.

The results from the economic analysis—using a pivotal shift—indicate that the net present value (NPV) of the investment in bean research is MX$ 29,420,210 (base-year=1994), when using a discount rate of 10%, which is the estimated cost of opportunity of capital in agricultural activities in Mexico. The estimated internal rate of return (IRR) is 21.4%, which is more than twice as much the discount rate used to compute the NPV. Therefore, since the economic point of view, investing in generating and promoting the use of improved bean varieties in northern Mexico has been a profitable investment under both the NPV and the IRR criteria. Higher values for the economic net present value and the internal rate of return, compared to the financial analysis estimates, are explained by the higher price level of imported beans (IPP) versus bean domestic prices.

Regarding the distribution of the benefits (change in total surplus of MX$ 153,116,040), over the period 1992-2000 (*i.e.*, the period when the improved varieties were adopted), change in consumer surplus was MX$ 251,644,325, and the change in producer surplus was MX$ -98,528,285. These results indicate that all of the benefits from the change in total surplus were captured by consumers and that producers actually have a loss, as result of the demand being inelastic (η=0.5).

6.5 Sensitivity Analysis

This section presents the sensitivity analysis performed on the results of both the financial and the economic analysis. Sensitivity analysis is used to evaluate the impact of uncertainty about future events and values on the baseline results. A sensitivity analysis is done by varying the value of one key variable or a combination of key variables, and determining the impact of that change on the result as measured by the IRR or the NPV (Gittinger 1982; ADB 1997).

6.5.1 Changes in Adoption and Yields

The financial and economic rates of return are very sensitive to changes in the adoption rate and incremental yields (Table 6.9). The switching value is the percentage changes in the variables for the NPV to become zero or the IRR to fall to the cut-off rate (*i.e.*, the OCC=10 percent).

Table 6.9 Sensitivity Analysis of Decreasing Changes in Adoption Rate and Incremental Yield.

Adoption Rate Decrease	Financial Rate of Return	Economic Rate of Return	Incremental Yield Decrease	Financial Rate of Return	Economic Rate of Return
0%	17.5%	21.4%	0%	17.5%	21.4%
-10%	15.4%	19.4%	-10%	15.2%	19.0%
-20%	12.9%	17.0%	-20%	12.3%	16.0%
-30%	9.7%	14.1%	-30%	8.5%	11.8%
-40%	5.2%	10.2%	-40%	1.9%	3.1%

If a 40 percent decrease in the adoption rate is assumed, the financial returns decrease from 17.5 to 5.2 percent (switching value=29% decrease) and the economic returns decrease from 21.4 to 10.2 percent (switching value=40.5% decrease), which implies a negative financial net present value because the opportunity cost of capital is 10 percent. However, a large decrease in the adoption rate (*e.g.*, 40%) for the improved pinto bean varieties is not likely to happen until better improved varieties are released.

If a 40 percent decrease in the incremental yield is assumed (*i.e.*, from 20% to 12%), the financial returns decrease from 17.5 to 1.9 percent (switching value=26.5% decrease) and the economic returns decrease from 21.4 to 3.1 percent (switching value=33% decrease), which implies negative net present values both financial and economic. In both cases, the economic rate of return is still higher than the financial rate of return, because imported beans are more expensive than domestically produced beans.

The 95% confidence interval for the mean yield of the improved pintos (section 5.4.2) indicates that the lower bounds are 10% and 4% below the mean for Pinto Mestizo and Pinto Villa, respectively. Therefore, a large decrease in incremental yields (*e.g.*, >26%) is not very likely.

6.5.2 Changes in Prices and Costs

The financial and economic rates of return are also very sensitive to changes in the domestic price and the import parity price, respectively (Table 6.10). If a 40 percent decrease in the domestic price is assumed, the financial rate of return decreases from 17.5 to 4.7 percent (switching value=28.4% decrease), which implies a negative net present value because the opportunity cost of capital is 10 percent.

A 40 percent decrease in the import parity price reduces the economic rate of return from 21.4 to 6.7 percent (switching value=35% decrease). However, the economic rate of return is less sensitive to changes in the official exchange rate. If an increase in the exchange rate (MX$/US$) is assumed, to account for potential overvaluation, making imported beans even more expensive relative to domestically produced beans, the economic rate of return also increases.

Table 6.10 Sensitivity Analysis for Changes in Prices and in the Official Exchange Rate.

Domestic Price[a] Decrease	Financial Rate of Return	Import Parity Price Decrease[b]	Economic Rate of Return	Exchange Rate Increase	Economic Rate of Return
0%	17.5%	0%	21.4%	0%	21.4%
-10%	15.3%	-10%	19.1%	10%	23.4%
-20%	12.7%	-20%	16.2%	20%	25.1%
-30%	9.4%	-30%	12.5%	30%	26.6%
-40%	4.7%	-40%	6.7%	40%	28.0%

a. The change in domestic price affects only financial returns.
b. The change in import parity price affects only economic returns.

The financial and economic rates of return are less sensitive to changes in research and extension costs (Table 6.11). However, a large increase in R&E costs would need to be assumed (40%) in order to decrease the financial rate of return from 17.5 to 9.9 percent and make the net present value negative (switching value=39.5% increase). For a very large increase in R&E costs (70%), the economic rate of return decreases from 21.4 to 9.2 percent (switching value=65.5% increase) and turns the NPV negative. The financial rate of return is not very sensitive to changes in the adoption costs, which depend basically on the subsidy for the price of the improved seed. Even assuming a complete elimination of the subsidy—a one hundred percent reduction—the financial rate of return is 14.0 percent, which is higher than the OCC (10 percent).

Table 6.11 Sensitivity Analysis for Changes in Research, Extension, and Adoption Costs.

Research and Extension Costs Increase	Financial Rate of Return	Economic Rate of Return	Adoption Costs (Seed Subsidy Decrease)[a]	Financial Rate of Return
0%	17.5%	21.4%	0%	17.5%
10%	15.6%	19.5%	-20%	16.9%
20%	13.6%	17.8%	-40%	16.2%
30%	11.8%	16.0%	-60%	15.5%
40%	9.9%	14.4%	-80%	14.8%
50%	8.0%	12.7%	-100%	14.0%
60%	6.0%	11.0%	--	--
70%	3.9%	9.2%	--	--

a. The change in subsidy level affects only financial returns.

6.5.3 Changes in Elasticities

The financial and economic rates of return are very sensitive to the estimates for the elasticity of supply (Table 6.12). If a supply elasticity (ε) of 0.1 is assumed, the financial and economic returns increase to 44.2 and 48.8 percent, respectively, but if a supply elasticity of 0.9 is assumed, the financial and economic rates of return decrease to 2.2 and 2.6 percent respectively, turning the NPVs negative. Break-even values are ε=0.70 and ε=0.77 for the financial and economic IRR, respectively.

Table 6.12 Sensitivity Analysis for Different Estimates of Supply and Demand Elasticity.

Supply Elasticity	Financial Rate of Return	Economic Rate of Return	Demand Elasticity	Financial Rate of Return	Economic Rate of Return
0.10	44.2%	48.8%	0.10	18.0%	21.8%
0.20	33.3%	37.7%	0.20	17.9%	21.7%
0.30	26.7%	31.0%	0.30	17.7%	21.5%
0.40	21.7%	25.8%	0.40	17.6%	21.5%
0.50	17.5%	21.4%	0.50	17.5%	21.4%
0.60	13.7%	17.3%	0.60	17.5%	21.3%
0.70	10.1%	13.2%	0.70	17.4%	21.3%
0.80	6.3%	8.7%	0.80	17.3%	21.2%
0.90	2.2%	2.6%	0.90	17.3%	21.2%

In contrast, the financial and economic returns have little sensitivity to changes in the demand elasticity estimate. If a demand elasticity (η) of 0.1 is assumed, the financial and economic returns only increase to 18.0 and 21.8 percent, respectively, but if a demand elasticity of 0.9 is assumed, the financial and economic returns will only decrease to 17.3 and 21.2 percent, respectively. In both cases the NPV is still positive for a large values of the elasticity of demand (*e.g.*, η=10).

The magnitude of the change in total surplus and the distribution of the benefits between consumers and producers (1992-2000) are very sensitive to the estimates for the elasticity of supply (Table 6.13). If a supply elasticity (ε) of 0.1 is assumed (and η=0.5), the financial and economic change in total surplus increase to MX$ 850,196,000 and MX$ 1,186,254,000, respectively and the largest share of the benefits goes to producers. If a supply elasticity of 0.9 is assumed, the financial and economic change in total surplus decrease to MX$ 22,823,000 and MX$ 35,431, respectively, and all benefits are captured by the consumers while producers actually lose from a more elastic supply.

Table 6.13 Sensitivity of Benefit Distribution to Different Estimates of Supply Elasticity.

Supply Elasticity	Financial Analysis (Thousands of MX$)			Economic Analysis (Thousands of MX$)		
	Change in Total Surplus	Change in Consumer Surplus	Change in Producer Surplus	Change in Total Surplus	Change in Consumer Surplus	Change in Producer Surplus
0.10	850,196	344,437	505,759	1,186,254	468,145	718,109
0.20	387,128	293,900	93,228	542,983	390,127	152,856
0.30	231,996	256,289	-24,293	327,203	332,121	-4,917
0.40	154,041	227,208	-73,167	218,636	287,306	-68,670
0.50	107,051	204,052	-97,001	153,116	251,644	-98,528
0.60	75,592	185,179	-109,586	109,206	222,592	-113,386
0.70	53,037	169,500	-116,463	77,694	198,468	-120,774
0.80	36,064	156,269	-120,205	53,960	178,116	-124,156
0.90	22,823	144,953	-122,130	35,431	160,717	-125,286

In contrast, the magnitude of the change in total surplus and the distribution of the benefits between consumers and producers (1992-2000) are not very sensitive to the estimates for the elasticity of demand (Table 6.14). If a demand elasticity (η) of 0.1 is assumed (and ε=0.5), the financial and economic change in total surplus increase only to MX$ 112,270,000 and MX$ 159,014,000, respectively and all benefits are captured by the consumers while producers actually lose. If a demand elasticity of 0.9 is assumed the financial and economic change in total surplus decrease only to MX$ 104,814,000 and MX$ 150,589,000, respectively and all benefits are captured by the consumers while producers actually lose—but the loss is proportionally smaller than when demand is more inelastic.

Table 6.14 Sensitivity of Benefit Distribution to Different Estimates of Demand Elasticity

Demand elasticity	Financial Analysis (Thousands of MX$)			Economic Analysis (Thousands of MX$)		
	Change in Total Surplus	Change in Consumer Surplus	Change in Producer Surplus	Change in Total Surplus	Change in Consumer Surplus	Change in Producer Surplus
0.10	112,270	335,738	-223,468	159,014	414,493	-255,479
0.20	110,406	289,107	-178,701	156,907	356,784	-199,877
0.30	109,008	253,842	-144,834	155,328	313,173	-157,846
0.40	107,921	226,242	-118,321	154,099	279,059	-124,960
0.50	107,051	204,052	-97,001	153,116	251,644	-98,528
0.60	106,339	185,826	-79,486	152,312	229,133	-76,821
0.70	105,746	170,587	-64,841	151,642	210,318	-58,676
0.80	105,245	157,658	-52,414	151,075	194,358	-43,283
0.90	104,814	146,551	-41,736	150,589	180,649	-30,060

Previous results are consistent with theory, which states that elasticity estimates are important in relation to the distribution of benefits. In particular, the more elastic supply is relative to demand, the greater the consumer share of total research benefits (and smaller the producer share) and vice versa (Alston *et al.* 1998).

6.6 The Small Open Economy Model

This section presents the formulas and estimations of research benefits in a small open economy model. The small open economy refers to a situation where the price is determined exoneously by the world price of the commodity (Alston *et al.* 1998). The small-country assumption may be appropriate for the case of Mexico, considering that dry beans are tradable and that the country does not have a significant influence on international prices. The financial analysis includes the government subsidy for the improved bean varieties and the NAFTA tariffs and quotas for importing beans into Mexico. For the economic analysis both the subsidy for bean seed and the tariffs and quotas for bean imports (market distortions) were removed.

6.6.1 Financial Analysis

In a small country, a tariff[16] on imports raises the domestic price above the world price (P_w) to a price equal to the world price plus the tariff rate ($[1+t]P_w$) and generates tariff revenue for the government. The research-induced supply shift reduces imports of the commodity and government revenues from the tariff. While the total benefit from research is unaffected by the tariff, producer benefits are greater, offsetting reduced government revenues from tariffs (Alston *et al.* 1998).

[16] A tariff and a quota are in some senses equivalent. In most analyses, the main difference between a tariff and an import quota is that the tariff generates tariff revenue for the government whereas the import quota generates quota rents, which are often private benefits (Alston 1998).

The formulas used in this study for the *ex post* assessment of research benefits from a pivotal supply shift are:

$\Delta GS=-tP_wQK\varepsilon$ $\Delta PS=0.5(1+t)P_wQK(1-K\varepsilon)$ $\Delta CS=0$ $\Delta TS=\Delta PS+\Delta GS$

where ΔGS=change in government revenue, t=*ad valorem* tariff (rate),

P_w=world price, Q=observed quantity produced, K=vertical supply shift expressed as a proportion of the product price, ε=elasticity of supply, ΔPS=change in producer surplus, ΔCS=change in consumer surplus, and ΔTS=change in total surplus.

Research and extension costs were subtracted to obtain the net changes in producer surplus and total surplus.

The results from the financial analysis—using a pivotal shift—indicate that the net present value (NPV) of the investment in bean research for a small open economy model is MX$ 26,331,431 (base-year=1994), when using a discount rate of 10% (OCC). The estimated internal rate of return (IRR) is 21.3%, which is more than twice the opportunity cost of capital.

Given that the NPV is positive and that the IRR is greater than the OCC, from the financial point of view, investing in generating and promoting the use of improved bean varieties in northern Mexico has been a profitable investment under both the NPV and the IRR criteria when assuming a small open country.

Regarding the distribution of the benefits (change in total surplus of MX$ 85,258,806), over the period 1992-2000 (*i.e.*, the period when the improved varieties were adopted), the change in consumer surplus was zero, the change in producer surplus was MX$ 224,372,237, and the change in government revenues was MX$ -139,113,431.

These results indicate that all of the benefits from the change in total surplus were captured by producers. Consumers didn't benefit from technological change because the output price is assumed to be exogenous. Additionally, there was a loss in tariff revenues to the government.

6.6.2 Economic Analysis

In a small open economy without market-distorting policies, all of the research benefits accrue to the producers in the innovating country (*i.e.*, Mexico), regardless of whether the country is an exporter or an importer (Alston *et al.* 1998). Given that a small country does not have a significant influence in the world price for beans, the research-induced supply shift does not reduce the domestic price, which remains equal to the world price. There is no change in consumer surplus because the price is relatively constant and the change in total surplus is equal to the change in producer surplus that results from the reduction in the cost per unit of output.

In the case of a small open economy, the formulas for the *ex post* assessment of research benefits from a pivotal supply shift are:

$$\Delta CS=0 \qquad \Delta PS=\Delta TS=0.5P_wQK(1-K\varepsilon)$$

where ΔCS= change in consumer surplus, ΔPS=change in producer surplus, ΔTS=change in total surplus, P_w=world price, Q=observed quantity produced, K=vertical supply shift expressed as a proportion of the product price, and ε=elasticity of supply.

This formula applies for both an exporter and an importer country in the absence of market distorting policies. Research and extension costs were subtracted to obtain the net changes in producer surplus and total surplus.

The results from the economic analysis—using a pivotal shift—indicate that the net present value (NPV) of the investment in bean research for a small open economy model is MX$ 24,405,096 (base-year=1994), when using a discount rate of 10% (OCC). The estimated internal rate of return (IRR) is 20.7%, which is twice as much the opportunity cost of capital. Given that the NPV is positive and that the IRR is greater than the OCC, from the economic point of view, investing in generating and promoting the use of improved bean varieties in northern Mexico has been a profitable investment under both the NPV and the IRR criteria when assuming a small open country. Lower values for the economic NPV and IRR, compared to the financial analysis estimates, are explained by the removal of the bean seed subsidy and the beans import tariffs and quotas. The difference is relatively small because in the financial analysis the research-induced supply shift also reduces the government revenues from the tariff.

Regarding the distribution of the benefits (change in total surplus of MX$ 152,848,491), over the period 1992-2000 (*i.e.*, the period when the improved varieties were adopted), the change in consumer surplus was zero, and the change in producer surplus was equal to the change in total surplus. These results indicate that all of the benefits from the change in total surplus were captured by producers. Consumers didn't benefit from technological change because the output price is assumed to be exogenous.

6.6.3 Closed versus Small Open Economy

Both the closed and small open economy models are used to analyze the rate of return to bean research because of the complexity of output pricing for beans in Mexico. In the closed economy model, the price of the commodity is determined inside the country but in the small open economy model the price is exogenous. In this study, a closed economy model is justified by the fact that the domestic price of beans clearly showed a decreasing trend in 1990-2000, while a decreasing trend in the international price was not so evident (section 6.1.2). In contrast, the small open economy model is justified by the increasing influence of the world price on the domestic price and the open economy model takes into account the effect of barriers to trade (i.e., tariffs and quotas). However, the case of the bean subsector in Mexico does not exactly matches either of these models. In fact, given that NAFTA evolved during the years considered in this study, these years represent a period of transition from a relatively closed economy to an open economy. For example, data from Chapter 3 (section 3.1.5) show that during 1991-2000, bean imports averaged 6% of total production and although net imports were positive, they averaged only 4% of total production. In addition, in five out of ten years (1991-1995), net imports were negative or nearly zero. Because beans are mostly grown under rainfed conditions in Mexico (85% of total planted area), the erratic weather conditions explain the large fluctuations in bean production and imports. Therefore, price setting for beans in Mexico depends not only on domestic production, but also on the world bean production (mainly the U.S.), which is also subject to large fluctuations from year-to-year due to changes in weather and market conditions.

Therefore, comparison of the estimates for the closed vs. small open economy model is intended to help in addressing this complexity. The results of the analysis indicate that there is very little difference in the rates of return for the economic analysis when estimated assuming a closed economy model (21.4%) vis-à-vis the small open economy model (20.7%). This result is as expected because in both cases the seed subsidy and bean import tariffs were removed, and the world price was used to compute the rates of return. In the case of the financial analysis, the rate of return is higher for the small open economy model (21.3%) than for the closed economy model (17.5%). In both cases, the seed subsidy is taken into account so the difference is explained by the use of the world price for the open economy model, which before the tariff is higher than the domestic price used for the closed economy model. In the open economy model, the greater producer benefit after the tariff is offset by the reduction in government revenues due to the decrease in bean imports.

The most important difference between the closed vs. small open economy model has to do with the distribution of benefits from the research-induced supply shift. In the closed economy model, for both the financial and economic analysis, all of the benefits from the change in total surplus are captured by consumers, while producers actually have a loss—when demand is inelastic—because technological change leads to a lower domestic price.

In contrast, in the case of the financial analysis for the small open economy model, instead of decreasing, the domestic price remains equal to the world price. Thus, all of the benefits from the change in total surplus are captured by producers, there is no change in consumer surplus, and there is a loss in government tariff revenues.

In the case of the economic analysis for the small open economy model, the fact that the output price is exogenous implies that all of the benefits from the change in total surplus are captured by producers and there is no change in consumer surplus after technological change.

As mentioned before, in the case of the closed economy model, consumers capture all of the benefits from research. The development and diffusion of improved bean varieties directly benefits all consumers by making larger quantities of beans (supply shift) available at lower prices. However, given that both consumption preferences and demand response to price changes vary with income, the impact differs among income classes. Because most staple commodities (*e.g.*, dry beans) are inferior goods (*i.e.*, have negative income elasticities), poorer people consume a greater quantity than richer consumers (Alston *et al.* 1998). Individually, low-income consumers tend to benefit relatively more from research to generate improved bean varieties than research on non-staple commodities (*e.g.*, export crops) because low-income consumers spend a high proportion of their income on beans.

In the case of the small open economy model, producers capture all of the benefits from research, but the impact among producer groups is different. Producers with different incomes, with different farm sizes, in different locations, and with diverse tenure situations can gain or lose, depending on the suitability of the new technology to their particular circumstances. Recent evidence suggests that neither farm size nor tenure have been a major impediment to adoption of new biological technologies (Alston *et al.* 1998). However, in this study, the evidence from the econometric analysis of program participation (section 5.5) indicates that in northern Mexico farmer participation in the seed distribution program is associated mainly with farm size and location. Smaller farmers located in marginal areas (which were targeted by the program) are more likely to participate in the program. Therefore, they benefit more from bean research than larger farmers with a better location (*i.e.*, closer to the city).

In addition, the observed decline in the real price of pinto beans (section 3.3.1) suggest that early adopters benefited more from technological change than late or non-adopters because at the beginning of the adoption process the price for the improved pintos was higher than the price of traditional pintos—until improved pintos gradually flooded the market.

For example, through the 1980s Ojo de Cabra was the dominant variety grown in Chihuahua. In 1990 CONASUPO (marketing parastatal) announced that in the future, it would no longer purchase this variety, since although preferred by local consumers, CONASUPO could not sell its surpluses of this variety in other regions of Mexico. Following this announcement, farmers began looking for a replacement variety, just at the time when Pinto Villa was being tested. As a result, commercial production of Pinto Villa, which began in 1992, expanded rapidly.

The incentives for farmers to adopt the new varieties were higher yields and higher prices (initially) than traditional varieties, due to a better market acceptance. The improved varieties have higher yields than traditional varieties because they are resistant to anthracnose—a disease causing serious crop losses—and tolerant to drought, the main problem in the region. At the beginning of the adoption process, farmers also benefited from higher prices for the improved pintos versus traditional varieties (*e.g.*, Ojo de Cabra), but as the relative amount of these beans in the market increased, prices declined. However, pintos still have better market acceptance. Thus, bean research benefited producers by generating new varieties that increased or maintained productivity and farmers' income.

6.7 Summary of the Chapter

In this chapter the returns to research investment for improved bean varieties in the north of Mexico are evaluated using the economic surplus method. During the period 1990-2000, INIFAP released several improved bean varieties for rainfed conditions, with the support of the B/C CRSP. For the purpose of the economic evaluation of bean research, the relevant improved varieties are Pinto Villa and Pinto Mestizo. The statistical analysis of Chapter 5 indicates that in both Chihuahua and Durango these two varieties have yields that are significantly higher (20.6%) than the traditional pinto market class variety Pinto Nacional.

Other improved varieties are not considered in the economic assessment because there is insufficient evidence that their yields are significantly higher than traditional varieties in the same market class. Similarly, Zacatecas is not included in the analysis, since the two improved pintos do not account for a major share of the state's bean area. However, research and extension costs for other varieties and for Zacatecas are included because they are part of the total cost of generating and promoting the improved varieties.

The first section of the chapter presents the data used for the analysis regarding: a) area, production, and yields; b) value of production and prices; c) INIFAP and CRSP research costs; d) extension and adoption costs; and e) the consumer price index and the exchange rate. Section two explains the assumption used in the analysis, regarding supply and demand elasticities, functional forms, and the adoption path. It also presents the formulas for the closed economy model which were used to compute the changes in total surplus (ΔTS), consumer surplus (ΔCS), and producer surplus (ΔPS), the net present value (NPV), and the internal rate of return (IRR). Sections three and four present the results of the financial and economic analysis, assuming a closed economy model. Section five reports the results of the sensitivity analysis. Section six presents the results of the financial and economic analysis, assuming a small open economy model and compares these results with results obtained using the closed economy model.

In the closed economy model, the results from the financial analysis indicate that the NPV of the investment in bean research is MX$ 17,681,052 (base-year=1994), when using a discount rate of 10%, which is the estimated cost of opportunity of capital (OCC) in agricultural activities in Mexico, and that the IRR is 17.5%. Therefore, from the financial point of view, investing in generating and promoting the use of improved bean varieties in northern Mexico has been a profitable investment under both the NPV and the IRR criteria. Regarding the distribution of the benefits between consumers and producers (change in total surplus of MX$ 107,051,062), over the period 1992-2000 (*i.e.*, the period when the improved varieties were adopted), the change in consumer surplus was MX$ 204,052,485, and the change in producer surplus was MX$ -97,001,423. These results indicate that the consumers captured all the benefit from the change in total surplus and that producers actually have a loss, as result of the demand being inelastic.

In the closed economy model, the results from the economic analysis indicate that the NPV of the investment in bean research is MX$ 29,420,210, (OCC=10%), and that the IRR is 21.4%. Therefore, from the point of view of the society as a whole, investing in generating and promoting the use of improved bean varieties in northern Mexico has been a profitable investment under both the NPV and the IRR criteria. The economic NPV and IRR, are higher than the financial analysis estimates because the higher price of imported beans (IPP), compared to domestically produced beans, more than offsets the removal of the subsidy to farmers on the price of the improved seed. Regarding the distribution of the benefits (change in total surplus of MX$ 153,116,040), the change in consumer surplus was MX$ 251,644,325, and the change in producer surplus was MX$ -98,528,285. These results indicate that the consumers captured all the benefits from the change in total surplus and that producers actually have a loss, as a result of the demand being inelastic.

Sensitivity analysis was carried out to assess the sensitivity of the rate of return to changes in the parameters used in the model. Sensitivity analysis estimated the switching values, defined as the percentage changes in the value of key variables that results in NPV to become zero or the IRR to fall to the cut-off rate (*i.e.*, the OCC=10 percent). For the adoption rate, the switching values are a 29% decrease for financial returns and a 40.5% decrease for economic returns. However, a large decrease in the adoption rate (*e.g.*, 40%) for the improved pinto bean varieties is unlikely to occur until better improved varieties are released. For the incremental yield, the switching value is a 26.5% decrease for financial returns and a 33% decrease for economic returns. However, the 95% confidence interval for the mean yield of the improved pintos (section 5.4.2) indicates that the lower bounds are 10% and 4% below the mean for Pinto Mestizo and Pinto Villa, respectively. Therefore, a large decrease in incremental yields (*e.g.*, >26%) is not very likely.

For the domestic price, the switching value is a 28.4% decrease for financial returns. For the IPP, the switching value is a 35% decrease for economic returns. In the case of the exchange rate, if an increase in the exchange rate (MX$/US$) is assumed, to account for potential overvaluation, making imported beans even more expensive relative to domestically produced beans, the economic rate of return also increases.

For research and extension cost the switching values are a 39.5% and a 65.5% increase for financial and economic returns, respectively. Changes in adoption costs depend basically on the subsidy for the price of the improved seed. Even assuming a complete elimination of the subsidy, the financial rate of return is 14.0 percent, which is still higher than the OCC.

If a supply elasticity (ε) of 0.1 is assumed, the financial and economic returns increase to 44.2 and 48.8 percent, respectively, but if a supply elasticity of 0.9 is assumed the financial and economic rates of return decrease to 2.2 and 2.6 percent respectively, turning the NPVs negative. Break-even values are ε=0.70 and ε=0.77 for the financial and economic IRR, respectively. This means that research investment remains profitable for ε<0.70 in the financial analysis and for ε<0.77 in the economic analysis.

If a demand elasticity (η) of 0.1 is assumed, the financial and economic returns only increase to 18.0 and 21.8 percent, respectively, but if a demand elasticity of 0.9 is assumed, the financial and economic returns will only decrease to 17.3 and 21.2 percent, respectively, which are still higher that the OCC. In both cases the NPV is still positive for a large values of the elasticity of demand (*e.g.*, η=10).

In addition, the sensitivity analysis was used to assess the distribution of the benefits between consumers and producers. If a supply elasticity (ε) is of 0.1 is assumed (and η=0.5), there is a large increase in total surplus and the largest share of the benefits is for the producers. If a supply elasticity of 0.9 is assumed (and η=0.5), there is a large decrease in total surplus and the consumers capture all benefits while producers actually lose from a more elastic supply.

If a demand elasticity (η) of 0.1 is assumed (and ε=0.5), there is a small increase in total surplus and all benefits are captured by the consumers while producers actually lose. If a demand elasticity of 0.9 is assumed (and ε=0.5),there is a small decrease in total surplus and the consumers capture all benefits while producers actually lose—although the loss is proportionally smaller than when demand is more inelastic.

In a closed economy model, the price of the commodity is determined inside the country and in a small open economy model the price is exogenous. In this study, a closed economy model is justified by the fact that the domestic price of beans clearly showed a decreasing trend in 1990-2000, while a decreasing trend in the international price was not so evident. The small open economy model is justified by the increasing influence of the world price on the domestic price and the open economy model takes into account the effect of barriers to trade (i.e., tariffs and quotas).

In the small open economy model, the results from the financial analysis indicate that the NPV of the investment in bean research is MX$ 26,331,431 (OCC=10%) and that the IRR is 21.3%, which implies that bean-research investment is financially a profitable investment under the small open country assumption. Regarding the distribution of the benefits (change in total surplus of MX$ 85,258,806), the change in consumer surplus was zero, the change in producer surplus was MX$ 224,372,237, and the change in government revenues was MX$ -139,113,431. These results indicate that all of the benefits from the change in total surplus were captured by producers.

Consumers didn't benefit from technological change because the output price is assumed to be exogenous. Additionally, there was a loss in tariff revenues to the government.

In the small open economy model, the results from the economic analysis indicate that the NPV of the investment in bean research is MX$ 24,405,096 (OCC=10%) and that the IRR is 20.7%, which implies that bean-research investment is economically a profitable investment under the small open country assumption. Lower values for the economic NPV and IRR, compared to the financial analysis estimates, are explained by the removal of the bean seed subsidy and the beans import tariffs and quotas. The difference is relatively small because in the financial analysis the research-induced supply shift also reduces the government revenues from the tariff. Regarding the distribution of the benefits (change in total surplus of MX$ 152,848,491), the change in consumer surplus was zero, and the change in producer surplus was equal to the change in total surplus. These results indicate that all of the benefits from the change in total surplus were captured by producers. Consumers didn't benefit from technological change because the output price is assumed to be exogenous.

Comparison of the results for the closed vs. small open economy model indicates that there is very little difference in the rates of return for the economic analysis when estimated assuming a closed economy model (21.4%) vis-à-vis the small open economy model (20.7%). This result is as expected because in both cases the seed subsidy and bean import tariffs were removed, and the world price was used to compute the rates of return. In the case of the financial analysis, the rate of return is higher for the small open economy model (21.3%) than for the closed economy model (17.5%). The difference is explained by the use of the world price for the open economy model, which before the tariff is higher than the domestic price used for the closed economy model.

The most important difference between the closed vs. the small open economy model has to do with the distribution of benefits from the research-induced supply shift. In the closed economy model, for both the financial and economic analysis, all of the benefits from the change in total surplus are captured by consumers, while producers actually have a loss—when demand is inelastic—because technological change leads to a lower domestic price. In contrast, in the case of the financial analysis for the small open economy model, instead of decreasing, the domestic price remains equal to the world price. Thus, all of the benefits from the change in total surplus are captured by producers, there is no change in consumer surplus, and there is a loss in government revenues from tariffs. In the case of the economic analysis for the small open economy model, the fact that the output price is exogenous implies that all of the benefits from the change in total surplus are captured by producers and there is no change in consumer surplus after technological change.

The case of the bean subsector in Mexico does not exactly matches either of these models. In fact, under the NAFTA the subsector is in a period of transition from a relatively closed economy to an open economy. Comparison of the estimates for the closed vs. small open economy model is intended to help in addressing this complexity.

CHAPTER 7. SUMMARY AND CONCLUSIONS

7.1 Summary of Findings

7.1.1 Challenges Facing the Bean Subsector

In Mexico dry beans are the second most important crop (after maize), both in terms of consumption and production. However, a variety of factors threaten this key agricultural subsector. First, during 1996-2000 the total harvested area decreased by 2.0% and average yield decreased by 2.5%, compared to 1990-1995. As a result, production declined 4.5% in 1996-2000, compared to 1990-1995.

Second, in Mexico, beans are grown during two seasons: the spring-summer (SS) season and the fall-winter (FW) season. However, most of Mexico's bean crop is grown during the SS season (84% of area and 73% of production) when yields are relatively low and highly variable from year-to-year because the crop is mainly grown under rainfed conditions in the semiarid highlands.

Third, since Mexico does not produce enough beans to meet its domestic requirements, it has been importing increasingly large quantities of beans (mainly pinto and black beans) to meet its domestic demand. Mexico has primarily imported beans from the U.S., since under the NAFTA import quotas and tariffs for imports of beans from the U.S. and Canada into Mexico are being phased out over the period 1994-2008. This increasing trend in bean imports highlights the problem facing domestic producers —the challenge of being competitive with imported beans.

Fourth, urbanization and income growth are having an important impact on consumer preferences. Increasingly, consumers are demanding new, more health-conscious, and convenient bean products of uniform quality. One implication is that increasingly, value is being added to beans after they are marketed by farmers. Value is added to beans through packing and the manufacturing of processed products. The processing industry primarily produces canned and dehydrated beans. During 1994-2000 the production of processed beans increased rapidly (3,314 to 53,515 Mt). However, this volume represents only about 4.4% of Mexico's annual bean production. About 40% of Mexico's processed bean output is exported to the U.S. Furthermore, while population increased by 46% during 1980-2000, total apparent consumption remain roughly unchanged. Thus, consumption per capita decreased by 18.5% during the period.

Fifth, in recent years the supply of various bean market classes has been poorly aligned with consumer demand. Although Mexico has a surplus of light color beans, it has a deficit of pinto and black beans. During 1993-1999, pinto beans accounted for an average of 25%, black beans for 29%, and light color beans for 46% of national production. On the other hand, pinto beans accounted for an average of 29%, blacks for 31%, and light color beans for 40% of national demand.

Sixth, until 1993, bean prices were determined mainly by the strong intervention of the government through guaranteed prices. But starting in 1993, the government initiated important changes to reduce government intervention in the agricultural sector and to allow prices to be determined according to a freer interaction of market supply and demand. As a result, real producer prices for beans declined 59% from 1990 to 2000. This drop in the real bean price is associated with price liberalization, which is designed to set prices in the domestic market to reflect prices in the world market, where bean prices have been declining. In the wholesale market, the decline in real prices has affected all market classes. During 1991-1999, domestic pinto beans faced the greatest real price decrease (-50%), followed by light color beans (-25%) and black beans (-22%). Furthermore, in the late 1990s, prices to U.S. producer for pinto and black beans declined, which contributed to the decline in Mexican bean prices since the U.S. is Mexico's most important source of imported beans.

Finally, one of the most important problems facing the bean subsector in Mexico is marketing. This is due not only to the complexity that arises from the diversity of demand for different market classes and quality of beans in regional markets, but is also due to the high level of concentration in the wholesale bean market, which results in large commissions to brokers, which in turn results in lower prices to producers and higher prices to consumers.

7.1.2 Government Intervention to Increase Productivity

Several institutions and programs have a mandate to serve the needs of the agricultural sector. First, the National Research Institute for Forestry, Livestock, and Agriculture (INIFAP) is charged with improving the standards of living of farmers and the population in general by generating technologies to increase agricultural production and productivity. Among other activities, INIFAP scientists have generated improved varieties for the most important crops in Mexico, including beans.

Second, The "Basic Program of Technical Assistance" (PEAT), a component of the Alliance for the Countryside, is responsible for promoting the use of technologies generated by research institutions and improving the quality of technical assistance services.

Third, the "National Producer of Seeds" (PRONASE), an organization of the federal government, promotes the production and utilization of certified seeds by multiplying seed from small quantities to commercial levels. Most of PRONASE's certified seed is bred by scientists at INIFAP and other research centers in the country.

In the early 1990s, to deal with the threat of the price liberalization, the Mexican government developed new strategies to support agricultural development. In 1994, the federal government started PROCAMPO, a fifteen-year cash transfer program to help farmers make the transition from a government-regulated to a market-driven agricultural sector. As a complement to PROCAMPO, in 1996 the government started "Alianza para el Campo" (Alliance for the Countryside), a broad strategy for promoting agricultural production and rural development. For bean farmers, one of the most relevant components of Alliance for the Countryside is the Kilo per Kilo program, which has the objective of increasing yields by encouraging farmers to substitute modern varieties for traditional varieties.

Since 1996, PRONASE has participated in Alliance for the Countryside by providing certified seed to the Kilo per Kilo program, which distributes certified seed (but also noncertified seed) to farmers at a price equivalent to that of commercial grain for a maximum of five hectares. A federal subsidy covers up to 45% of the difference between the price of the improved seed and the price of commercial grain. In addition, state governments are allowed to cover up to 55% of the price difference. This significant reduction in price makes improved seed very affordable to farmers. During 1996-2000, the Kilo per Kilo program distributed 12,077 Mt of bean seed to 127,209 farmers, who planted 384,525 ha in Chihuahua, Durango and Zacatecas in northern Mexico. SAGAR estimated that yields in the demonstration plots increased from 26% to 44%. The quantity of seed distributed increased from 1996 to 1998, but decreased from 1998 to 2000, depending on the annual budget assigned to the Kilo per Kilo program. During 1996-2000, SAGAR's total investment in the program was MX$ 90,924,000, most of which (98%) represented the cost of the seed that averaged MX$ 7.53 per kilo. Two categories of seed were distributed: certified seed (25%) and non-certified seed (75%), although some varieties were distributed under both categories. The certified varieties were PintoVilla (34%), Flor de Mayo (29%), Pinto Mestizo (18%), and other (19%). The non-certified varieties were Pinto Nacional (51%), Negro Criollo (21%), Pinto Villa (11%), and other (17%).

7.1.3 Farmers' Adoption of Improved Bean Varieties

During August-October 2001, a stratified random sample of bean farmers in Northern Mexico was selected and the farmers were interviewed. In the analysis, the farmers were divided into two groups: non-adopters and adopters. For Durango (n=206), 43% of the respondents were non-adopters and 57% were adopters. For Chihuahua (n=163), 17% were non-adopters, and 83% were adopters. For Zacatecas (n=86), 38% were non-adopters, and 62% were adopters. In total (n=455), 33% of the sampled farmers were non-adopters and 67% were adopters.

When comparing adopters vs. non-adopters, the statistical analysis indicates that these groups are quite similar with respect to age, experience, education, land tenure, farm size, bean area, soil quality, soil preparation, planting dates, cultural practices, and number of family members having off-farm employment. Adopters' participation in the Kilo per Kilo program was 65% in Durango, 35% in Chihuahua, and 45% in Zacatecas.

The analysis of farmers' selling price by market class shows that in general, light color beans sold for the highest prices, followed by pintos, and black beans—which sold for the lowest price. However, there were few statistically significant differences.

The percentage of the total area planted to improved varieties varied greatly from state-to-state, ranging from 71% in Chihuahua (Pinto Villa 56% and Pinto Mestizo 15%), to 42% in Durango (Pinto Villa 38% and Pinto Mestizo 4%), and 8% in Zacatecas (Negro Zacatecas).

The statistical analysis of farmers' yields indicates that while improved pintos had higher yields than traditional pintos (20.6%), there is no evidence that improved varieties of other market classes (black and light-colored beans) have higher yields than their respective traditional variety.

Finally, the surveyed adopters were asked about their perceptions regarding the advantages of improved varieties, compared to traditional varieties. The analysis of these data indicates that better consumption quality, market acceptance, fewer days to maturity (which is related to drought resistance), diseases resistance, and higher yields are the most salient characteristics that influenced farmers' decision to adopt improved varieties.

7.1.4 Econometric Analysis of Program Participation

The descriptive statistics show that the Kilo per Kilo program is the driving force for the adoption of improved bean varieties in northern Mexico. Almost all farmers who planted improved bean varieties either participated in the program during 2001, or had participated in an earlier year. Therefore, an econometric analysis of program participation was carried out to investigate the factors explaining the participation of farmers in the Kilo per Kilo program. A probit model, with the binary dependent variable "program" to indicate program participation, was estimated using the maximum likelihood method.

The regression analysis indicates that smaller farmers are more likely to participate in the program than larger farmers. The results also suggest that the farmer's perception of a higher percentage of dry years, the use of insecticide, tied-ridger ownership, and a greater distance from the farm to the city have a positive effect on program participation.

The econometric analysis confirms that in northern Mexico the participation of farmers in the seed distribution program is associated mainly with farm size and location. Smaller farmers located in marginal areas are more likely to participate in the program than larger farmers with better location (*i.e.*, closer to the city), which is consistent with the objectives of the Kilo per Kilo program for the distribution of improved bean varieties.

7.1.5 Returns to Bean-Research Investment

The returns to the research investment for improved bean varieties in the north of Mexico are evaluated using the economic surplus method. During the period 1990-2000, INIFAP released several improved bean varieties for rainfed conditions, with the support of the Bean/Cowpea CRSP. For the purpose of the economic evaluation of bean research, the relevant improved varieties are Pinto Villa and Pinto Mestizo. The statistical analysis indicates that in both Chihuahua and Durango, the yields of these two varieties are significantly higher (20.6%) than the traditional pinto market class variety, Pinto Nacional.

The evaluation of returns to research was carried out using both a closed economy model and a small open economy model. In a closed economy model, the price of the commodity is determined inside the country and in a small open economy model the price is exogenous. In this study, a closed economy model is justified by the fact that the domestic price for beans showed a clear decreasing trend during 1990-2000, while a decreasing trend in the international price was not so evident. However, the small open economy model is justified by the increasing influence of the world price on the domestic price and this model take into account the effect of barriers to trade (i.e., tariffs and quotas).

Closed Economy Model

The results from the financial analysis indicate that the NPV of the investment in bean research is MX$ 17,681,052 (base-year=1994), when using a discount rate of 10%, which is the estimated cost of opportunity of capital (OCC) in agricultural activities in Mexico, and that the IRR is 17.5%. Therefore, from the financial point of view, investing in generating and promoting the use of improved bean varieties in northern Mexico has been a profitable investment under both the NPV and the IRR criteria. Regarding the distribution of the benefits between consumers and producers (change in total surplus of MX$ 107,051,062), over the period 1992-2000 (*i.e.*, the period when the improved varieties were adopted), the change in consumer surplus was MX$ 204,052,485, and the change in producer surplus was MX$ -97,001,423. These results indicate that consumers captured all the benefit from the change in total surplus and that producers actually had a loss, as a result of the demand being inelastic.

The results from the economic analysis indicate that the NPV of the investment in bean research is MX$ 29,420,210, (OCC=10%), and that the IRR is 21.4%. Therefore, from the point of view of the society as a whole, investing in generating and promoting the use of improved bean varieties in northern Mexico has been a profitable investment under both the NPV and the IRR criteria. The economic NPV and IRR are higher than the financial analysis estimates because the higher price of imported beans (IPP), compared to domestically produced beans, more than offsets the increase in the price of the improved seed that resulted from removing the seed subsidy.

Regarding the distribution of the benefits (change in total surplus of MX$ 153,116,040), the change in consumer surplus was MX$ 251,644,325, and the change in producer surplus was MX$ -98,528,285. These results indicate that the consumers captured all the benefits from the change in total surplus and that producers actually have a loss, as a result of the demand being inelastic.

Sensitivity analysis was carried out to assess the sensitivity of the rate of return to the parameters used in the model. In the financial analysis, the switching values[17] for key variables were: adoption rate (29% decrease), incremental yield (26% decrease), and domestic price (28.4% decrease). In the economic analysis the switching values for key variables were: adoption rate (40.5% decrease), incremental yield (33% decrease), and import parity price (35% decrease). The switching values indicate that the IRR is less sensitive to changes in the market exchange rate, research and extension cost (seed price subsidy), and demand elasticity estimates.

[17] The switching value is the percentage change in the variable for the NPV to become zero or the IRR to fall to the cut-off rate (*i.e.*, the OCC=10 percent).

The economic rate of return is also sensitive to the estimates for the elasticity of supply. If a supply elasticity of 0.1 is assumed, the economic IRR increases from 21.4 to 48.8 percent. In contrast, if a supply elasticity of 0.9 is assumed, the economic IRR decreases from 21.4 to 2.6 percent, which is lower than the opportunity cost of capital (10%). Break-even values is ε=0.77 for the economic IRR. This means that research investment remains profitable for ε<0.77 in the economic analysis.

In addition, sensitivity analysis was used to assess the distribution of the benefits between consumers and producers. If a supply elasticity (ε) of 0.1 is assumed (and η=0.5), there is a large increase in total surplus and the largest share of the benefits go to the producers. If a supply elasticity of 0.9 is assumed, there is a large decrease in total surplus and the consumers capture all benefits, while producers actually lose as a result of a more elastic supply. In contrast, the distribution of benefits between consumers and producers is not very sensitive to the estimates for the elasticity of demand (η).

Small Open Economy Model

The results from the financial analysis indicate that the NPV of the investment in bean research is MX$ 26,331,431 (OCC=10%) and that the IRR is 21.3%, which implies that bean-research investment is financially a profitable investment. However, regarding the distribution of the benefits (change in total surplus of MX$ 85,258,806), the change in the consumer surplus was zero, the change in the producer surplus was MX$ 224,372,237, and the change in government revenues was MX$ -139,113,431. These results indicate that all of the benefits from the change in total surplus were captured by producers. Consumers didn't benefit from technological change because the output price is assumed to be exogenous. Additionally, there was a loss in tariff revenues to the government.

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Closed vs. Small Open Economy Model

The results for the closed vs. the small open economy model indicate that there is little difference between the economic rates of return under the assumptions of the closed economy model (21.4%) vis-à-vis the small open economy model (20.7%). This result is as expected because in both cases the seed subsidy and bean import tariffs were removed, and the world price was used to compute the rates of return. In the case of the financial analysis, the rate of return is higher for the small open economy model (21.3%) than for the closed economy model (17.5%). This difference is explained by the use of the world price in the open economy model, which before the tariff is higher than the domestic price used in the closed economy model.

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In contrast, in the case of the financial analysis for the small open economy model, instead of decreasing, the domestic price remains equal to the world price. Thus, all of the benefits from the change in total surplus are captured by producers, there is no change in consumer surplus, and there is a loss in government revenues from tariffs. In the case of the economic analysis for the small open economy model, the fact that the output price is exogenous implies that all of the benefits from the change in total surplus are captured by producers and there is no change in consumer surplus after technological change.

The case of the bean subsector in Mexico does not exactly matches either of these models. In fact, during the years covered by this study when NAFTA was evolving, the subsector was in transition from a relatively closed economy to an open economy. Thus, the estimates for both the closed and the small open economy models are presented to illustrate the impact of the closed vs. small open economy assumptions on the rate of return and on the distribution of the benefits from research.

7.1.6 Benefits for Consumers and Producers

In the case of the closed economy model, the results from the financial and economic analysis show that consumers are the major beneficiaries of bean research, because they capture all the increase in the total surplus. The development and diffusion of improved bean varieties directly benefits all consumers by making larger quantities of beans (supply shift) available at lower prices. However, given that both consumption preferences and demand response to price changes vary with income, the impact among income classes differs. Because most staple commodities (*e.g.*, dry beans) are inferior goods (*i.e.*, have negative income elasticities), poorer people consume a greater quantity than richer consumers (Alston *et al.* 1998). Individually, low-income consumers tend to benefit relatively more from research to generate improved bean varieties than research on non-staple commodities (*e.g.*, export crops) because low-income consumers spend a high proportion of their income on beans.

In the case of the small open economy model, the results from the financial and economic analysis show that producers capture all of the benefits from research, but the impact among producer groups differs. Producers with different incomes, with different farm sizes, in different locations, and with diverse tenure situations can gain or lose, depending on the suitability of the new technology to their particular circumstances.

In this study, the evidence from the econometric analysis of program participation (section 5.5) indicates that in northern Mexico farmer participation in the seed distribution program is associated mainly with farm size and location. Smaller farmers located in marginal areas are more likely to participate in the program. Therefore, they benefit more from bean research than larger farmers with a better location (*i.e.*, closer to the city). In addition, the observed decline in the real price of pinto beans (section 3.3.1) suggest that early adopters benefited more from technological change than late or non-adopters. This is because at the beginning of the adoption process the price for improved pintos was higher than the price of traditional pintos—until improved pintos gradually flooded the market (section 6.6.3).

7.2 Policy Implications

These results have implications for government decision-makers, bean researchers, and the extension services—all of whom are important agricultural research investment stakeholders.

7.2.1 Implications for Government Decision-Makers

It is widely accepted among economists that there is market failure in the provision of agricultural research by the private sector and that, without action by the government, there would be an underinvestment in research. Market failures arise when firms cannot appropriate all of the benefits of their research investments and as a result the market does not provide the private sector with sufficient incentives for it to invest at the level that would be best from society's point of view.

Given that beans are "self-pollinated", farmers do not have to purchase new seed every year. Thus, improved bean varieties have the characteristics of a public good[18]. With appropriate management, farmers can save and share or sell the seed to other farmers, without experiencing a significant reduction in yields from one year to the next. This leads to a lack of financial incentives, which explains why there is minimal private

[18] A good that once produced is available to all on a nonexclusive basis.

sector[19] participation in research to generate improved bean varieties, bean seed production, and seed marketing. The positive results from this economic analysis indicate that there is a strong case for public investment in research and extension to develop and distribute improved bean varieties in rainfed areas of northern Mexico.

In northern Mexico, farmer adoption of improved bean varieties has been highly dependent on government investment (SAGAR) in bean research (ARTTP-INIFAP), seed production (PRONASE and SNICS), seed distribution (Kilo per Kilo), and technical assistance (PEAT). Thus, the government should continue to invest in these programs to ensure that research benefits society, especially poor consumers and small farmers.

7.2.2 Implications for Bean Researchers

The success of the improved pinto bean varieties *(i.e.*, Pinto Villa and Pinto Mestizo) in Chihuahua and Durango; the success of the collaborative research between INIFAP and the Bean/Cowpea CRSP, which led the release of these varieties; the limited impact of improved varieties in Zacatecas; the increasing trend in bean imports; and changes in consumer preferences have the following implications:

- The bean research program should continue to focus on generating improved varieties that perform well in farmers' fields and are highly acceptable in the market. To achieve this goal, social scientists must continue to solicit feedback from farmers and market agents regarding their needs and preferences.
- Further collaboration with international programs (*e.g.*, the Bean/Cowpea CRSP) that supports international research partnerships or strategic alliances to increase the

[19] Although some farmers make contracts with the government through PRONASE to produce certified seed for the Kilo per Kilo program.

availability of beans and to increase the scope and the efficiency of research investments should be supported.

- The breeding program needs to strengthen its efforts to develop improved bean varieties of the dominant market class grown in Zacatecas (black beans) that have higher yields than existing varieties and other characteristics that are desired by producers and domestic consumers. This is very important because Zacatecas accounts for 37% of the total rainfed bean area, which is more than the area of Chihuahua and Durango together (25%).
- Priority should be given to generating improved bean varieties in the market classes in which there are large deficits that are currently being met through imports (*e.g.*, pinto and black beans) vs. those market classes for which there is a surplus and face marketing problems (*e.g.*, light color beans).
- Given the decreasing trend in consumption per capita and the increasing demand for value-added products, closer coordination is needed among researchers, producers, and processors to insure that future varieties meet the requirements of the industry and niche export markets.
- Continued collaboration between agronomist and social scientists is needed to periodically evaluate the on-farm performance of improved bean varieties after they are released and distributed to farmers.

7.2.3 Implications for Extension Services

The Kilo per Kilo seed distribution program has played a key role in the diffusion of research results and farmer adoption of new bean technologies. However, the variability in the operations of the program from year-to-year, from one state to another, and in the type of seed distributed (certified vs. non-certified), as well as the scarcity of seed, implies that the program needs to:

- Identify more stable funding mechanisms that will allow the program to set priorities and make plans to promote the improved varieties, without there being a lack of continuity in seed distribution.
- Provide better financial incentives[20] in the contracts with the growers who multiply the seed, to ensure that they produce a sufficient quantity and diversity of seed to meet the farmers' seed demand for different production regions and market classes.
- Increase the percentage of certified seed distributed (25%) vs. the noncertified seed (75%), given that farmers prefer certified seed because its physical, physiological, phytosanitary, and genetic quality are guaranteed.
- Provide farmers training on the appropriate management practices required to preserve seed quality from season-to-season, so that the program doesn't have to provide seed to the same farmers every year and, thereby, more farmers will benefit from the seed distribution program.

7.3 Limitations of the Study

The most important limitations of this study are:

- The surveys focused on the main bean-producing counties in each state where the Kilo per Kilo seed distribution program operated. However, there are other counties

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[20] Interviews with key informants indicated that from 1999 to 2000 the price paid to growers by the government for certified seed decreased and that seed growers believe that the price they receive hardly covers the costs of production of the seed and the risks they have to face.

producing beans and where the program operated, which were not included in the surveys.

- The survey included current data for yields in 2001, but the information used for 1997-2000 was based on farmers' recall. This historical information was likely less accurate than the current data and the historical data contained missing values for earlier years.
- There are no empirically-based estimates of supply and demand elasticities for dry beans in Mexico, so the estimates for these economic parameters were assumed based on estimations reported for the same or similar crop in other countries.
- There are intangible costs and benefits (*i.e.*, pollution from chemical inputs or preventing deterioration of the environment) associated with the impact of bean research that were not addressed in this study because, even if they can be identified, by definition they are hard to quantify and are difficult to value in monetary terms.
- A risk analysis was not included because information on the probability of changes in the key variables was not available to estimate their effect on research benefits.

7.4 Future Research Needs

The most important research issues that need to be addressed by future socioeconomic research studies are to:

- Apply the economic surplus approach to estimating the returns to research investment to other important crops and regions in Mexico, and to research results from INIFAP and other centers in the country for improved varieties and other technologies.

- Assess options for improving the price that farmers receive for their beans by marketing collectively to processors, urban wholesalers, and to export markets.
- Assess the feasibility of farmers' groups adding value to their product by cleaning, sorting, grading, and packing their beans.
- Identify alternative institutional arrangements for multiplying and marketing seed of improved varieties, given that the availability of certified seed represents a bottleneck for the diffusion of the improved bean varieties.
- Disaggregate the consumer and producer surplus (that results from the research-induced supply shift for beans) by using various categories of domestic consumers (*e.g.*, according to income class) and various categories of producers (*e.g.*, according to farm size, tenure, or location) to identify the impact of technical change for each group.
- Analyze the multiple social objectives of research (*e.g.*, economic efficiency, equity, reduce income risk, and national food security or self-sufficiency) to determine whether or not those objectives can be achieved through public-sector agricultural research or can be better pursued using alternative policies.
- Carry out an institutional analysis to better understand how the institutional setting affects economic performance. Institutions affect how research and extension organizations operate, so it is important to analyze how change in institutions (*e.g.*, property rights and policies) can affect the magnitude and distribution of research benefits.

APPENDICES

Appendix A: Farmer Questionnaires in Spanish and English

ENCUESTA SOBRE ADOPCION DE VARIEDADES MEJORADAS DE FRIJOL EN EL DISTRITO DE GUADALUPE VICTORIA, DURANGO, MEXICO 2001

INIFAP-SAGARPA

INFORMACION BASICA

Nombre del Agricultor ______________________ Número de Cuestionario _______

Localidad ______________________ Municipio ______________________

Nombre del encuestador ______________________ Fecha ______________

<u>DECLARACION DE CONSENTIMIENTO</u>

<u>(Antes de comenzar la entrevista, lea la siguiente declaración al agricultor)</u>

Mi nombre es <u>Horacio González.</u> Estoy llevando a cabo un estudio sobre la producción de frijol en México. Me gustaría hacerle algunas preguntas acerca de sus actividades de producción de frijol. La información que usted provea será usada para entender mejor las decisiones de producción de frijol de los agricultores, especialmente su elección de las variedades que ellos siembran. La información que yo obtenga de usted y de otros productores de frijol en el área será usada para completar mi disertación doctoral en el Departamento de Economía Agrícola en Michigan State University, EUA.

Este estudio es financiado por el INIFAP, en colaboración con el Proyecto de Financiamiento e Investigación Colaborativa (CRSP) para Frijol/Cowpea de Michigan State University, EUA.

Su participación es <u>VOLUNTARIA</u>. El que usted se rehúse o se retracte de participar en el estudio no implica ninguna acción penal ni la pérdida de ningún beneficio. Completar la entrevista tomará aproximadamente 60 minutos. Usted es libre de <u>NO CONTESTAR</u> cualquiera de las preguntas que yo le haré. Sin embargo, espero que usted esté de acuerdo en contestar todas mis preguntas, ya que sus respuestas me ayudarán a entender mejor el sistema de cultivo de frijol en Durango y por qué los agricultores prefieren diferentes variedades de frijol. Toda la información que usted provea se mantendrá <u>CONFIDENCIAL</u>. Esto significa que sus respuestas a mis preguntas no serán mostradas a nadie más. Nadie conocerá sus respuestas excepto yo, y su identidad será protegida en cualquier reporte basado en la información. Su privacidad será protegida hasta el límite máximo permitido por la ley.

Si usted tiene cualquier pregunta acerca de este estudio, por favor contacte al Profesor Richard Bernsten, Departamento de Economía Agrícola, Michigan State University, 211 E Agriculture Hall, East Lansing, MI o llame al Profesor Bernsten al (517) 355-3449. Si tiene preguntas sobre sus derechos y su papel como objeto humano de investigación, por favor contacte al Dr. David Wright, Michigan State University, 248 Administration Building, East Lansing, MI o llame al Dr. Wright al (517) 355-2180.

Estoy de acuerdo en que mi participación es voluntaria y acepto ser entrevistado.

Firma del Agricultor ______________________

I. INVENTARIO DE TIERRAS

Primero me gustaría preguntarle sobre las parcelas que sembró en el año 2001.

1.1 ¿Considerando todas las parcelas cuántos diferentes cultivos sembró en 2001?

1.2 ¿Cuántas hectáreas sembró de cada cultivo (incluyendo todas las parcelas)?

1.3 ¿Cómo clasificaría la calidad de la tierra de las parcelas (Buena; Regular; Mala)?

1.4 ¿Qué derechos de propiedad tiene sobre las parcelas (Ejido; Pequeña Propiedad; Aparcería)?

1.5 ¿Qué tipo de semilla sembró de cada cultivo (Certificada, Mejorada, Criolla)?

1.1 Cultivo	1.2 Hectáreas	1.3 Calidad	1.4 Tenencia	1.5 Tipo de Semilla
1 Frijol				
2				
3				

Tipo de semilla: C = certificada; M = mejorada o grano apto; R = Criolla

II. ACCESO A INFORMACION TECNICA

En seguida, me gustaría preguntarle de qué forma recibe Ud. información tocante a mejores maneras de producir frijol y acerca de la existencia de nuevas variedades de frijol.

2.1 En el último año ¿qué asesoría técnica recibió usted para mejorar sus rendimientos de frijol?

(Especifique) ____

____

En el último año, usted ha recibido información sobre nuevas variedades por medio de:

2.2 Radio/TV .... (0=No, 1=Si) ______

2.3 Periódico .... (0=No, 1=Si) ______

2.4 Folleto de extensión .... (0=No, 1=Si) ______

2.5 SAGARPA .... (0=No, 1=Si) ______

2.6 Compañía de seguros .... (0=No, 1=Si) ______

2.7 Banco .... (0=No, 1=Si) ______

2.8 Otro agricultor .... (0=No, 1=Si) ______

2.9 Parcelas demostrativas .... (0=No, 1=Si) ______

2.10 INIFAP .... (0=No, 1=Si) ______

2.11 Técnicos PEAT/SINDER .... (0=No, 1=Si) ______

2.12 Otro (Especifique)____

USO DE INSUMOS (indique qué labores realizó)

2.13 Barbechó (SI/NO) _________ 2.17 Primer escarda (SI/NO) _______

2.14 Rastreó (SI/NO) __________ 2.18 Deshierbó (SI/NO) _______

2.15 Fecha de siembra _________ 2.19 Segunda escarda (S/N) _______

2.16 Fertilizó (SI/NO) _________ 2.20 Insecticida (SI/NO) _______

III. VARIEDADES SEMBRADAS DE FRIJOL Y COSTO

Ahora quisiera preguntarle sobre las variedades de frijol que ha sembrado en los últimos años.

3.1 ¿Qué variedades de frijol ha sembrado en los años 1997-2001 (Certif., Mejorada, Criolla)?

3.2 ¿Dónde obtuvo la semilla que sembró?

3.3 ¿Qué precio pagó por la semillla ($/kg)?

3.4 ¿Cuántas hectáreas sembró de cada variedad?

3.5 ¿ Qué rendimiento obtuvo de cada variedad (kg/ha)?

Año	3.1 Variedad (C, M, R)	3.2 Dónde obtuvo la Semilla de frijol	3.3 Precio ($/kg)	3.4 Superficie (ha)	3.5 Rendto (kg/ha)
2001	1				
	2				
	3				

(Continúa)

(Continuación)

Año	3.1 Variedad (C, M, R)	3.2 Dónde obtuvo la semilla de frijol	3.3 Precio ($/kg)	3.4 Superficie (ha)	3.5 Rendto (ton/ha)
2000	1				
	2				
	3				
1999	1				
	2				
	3				
1998	1				
	2				
	3				
1997	1				
	2				
	3				

Tipo de semilla: C = certificada; M = mejorada o grano apto; R = Criolla

3.6 ¿Generalmente puede usted obtener suficiente cantidad de semilla de la variedad de frijol que desea sembrar? .... (0=No, 1=Si) _______

SI LA RESPUESTA ES "NO"

3.7 ¿Cuál es el problema? (Especifique) ______________________________

3.8 ¿De los pasados 10 años cuántos fueron años malos para producir frijol? ___________

3.9 ¿Cuántas personas ocupa cultivando frijol? Familia + Ud. ________ Contrata ________

3.10 ¿Cuál fue su costo de produccción por hectárea ($/ha)? ____________________

IV. CREDITO

En seguida, quisiera preguntarle en relación con su disponibilidad de credito.

4.1 Durante el año 2001, recibió algún crédito para financiar sus actividades de producción de frijol?.. (0=No, 1=Si) _______

SI LA RESPUESTA ES "SI"

4.2 ¿De quién recibió el crédito? (Especifique) ________________________________

4.3 ¿Cuánto crédito recibió ($/ha)? ________________________________

4.4 ¿Para qué usó el crédito? (Especifique) ________________________________

V. MAQUINARIA

En seguida, me gustaría preguntarle acerca la maquinaria que usa en la producción de frijol.

5.1 ¿Tiene usted tractor propio? .... (0=No, 1=Si) ______

SI LA RESPUESTA ES "NO"

5.2 ¿Cómo obtiene acceso a un tractor? (Especifique) ________________________________

5.3 ¿Tiene usted pileteadora propia? .... (0=No, 1=Si) ______

VI. VENTAS DE FRIJOL

En seguida, me gustaría preguntarle en torno a sus ventas de frijol.

6.1 ¿Cuántas toneladas vendió de cada variedad en el año 2000?

6.2 ¿A quién le vendió cada una de estas variedades?

6.3 ¿Cuál fue el precio que recibió por cada variedad ($/kg)?

6.4 ¿Cree Ud. que éste es un buen precio para ésta variedad?

6.5 SI LA RESPUESTA ES "NO": ¿Por qué no?

Nombre de la Variedad	6.1 Ventas (ton)	6.2 A quién le vendió?	6.3 Precio ($/kg)	6.4 ¿Buen precio?	6.5 Si "NO" ¿Por qué no?
1					
2					
3					

6.6 ¿Cuántos de su familia trabajan fuera de la parcela (incluyéndolo a Ud.)? ____________

6.7 ¿Cuántos meses al año trabajan? Ud _____ esposa _____ otros: a_____ b_____ c_____

6.8 ¿Usualmente qué hace Ud. con la paja de su cosecha de frijol? (Especifique) __________

____

6.9 ¿Cree usted que algunas variedades producen más paja? .... (0=No, 1=Si) _______

6.10 SI LA RESPUESTA ES "SI": ¿Cuáles variedades producen más paja? (Especifique) ____

____

VII. EVALUACION DE NUEVAS VARIEDADES DE FRIJOL

En seguida, me gustaría preguntarle su opinión sobre las variedades de frijol que el INIFAP ha liberado durante los últimos 10 años, comparadas con su semilla criolla ________________

(Nombre de la criolla)

¿Cómo compara la variedad mejorada con la criolla, en cuanto a:

7.1 Rendimiento (ton/ha)?

7.2 Aceptacion del mercado?

7.3 Resistencia a sequía?

7.4 Resistencia a plagas?

7.5 Escape a heladas?

7.6 Desgrane de vaina a la cosecha?

7.7 Resistencia a enfermedades?

7.8 Tipo de planta (forma)?

7.9 Dias a madurez?

7.10 Calidad para consumo?

Escala: P = Peor   I = Igual   M = Mejor   N = No opina/No sabe

Variedad Mejorada	7.1 RE	7.2 AM	7.3 RS	7.4 RP	7.5 EH	7.6 DC	7.7 RE	7.8 TP	7.9 DM	7.10 CC
1										
2										
3										

(Var.Mej. = Pinto Villa, P.Mestizo, P.Bayacora, Negro Altiplano, Negro Sahuatoba, etc.)

VIII. PARTICIPACION EN PROGRAMAS DEL GOBIERNO

8.1 ¿Para cuántas hectáreas recibió subsidio de Procampo ($829/ha)? ________________ ha

8.2 ¿Cuántos kilos de semilla certificada recibió del programa Kilo por Kilo? __________ kg

8.3 ¿Qué variedad recibió de KxK y a qué precio? __________________ _________ $/kg

8.4 ¿Otro apoyo del gobierno (Pronasol)? ¿Cuál? ____________________ _________ $/ha

IX. INFORMACION SOCIOECONOMICA

En seguida, me gustaría hacerle unas preguntas relacionadas con usted.

9.1 ¿Qué edad tiene? ___________________

9.2 ¿Hasta qué año estudió? ___________________

9.3 ¿Por cuántos años ha sembrado frijol? ___________________

9.4 ¿Es Ud. miembro de alguna asociación de agricultores? ¿Cuál? ____________________

9.5 SI LA RESPUESTA ES "SI": ¿Esta asociación ha influenciado su decisión acerca de la variedad de frijol que ha sembrado .... (0=No, 1=Si) _______

9.6 SI LA RESPUESTA ES "SI": ¿Cómo? (Especificar) __________________________

9.7 ¿Usualmente cuantas toneladas de frijol almacena usted antes de vender? _________ ton

9.8 ¿Por lo general cuántos meses almacena el frijol antes de vender? ____________ meses

X. COSTOS DE TRANPORTE

10.1 ¿Cuál es la distancia _____ km y tiempo _____ hr de su parcela a la ciudad más cercana?

¡GRACIAS POR SU AYUDA!

A. ¿Le gustaría hacer algún comentario adicional? _________________________________

____

B. Comentarios adicionales del encuestador ____________________________________

____

C. ¿Podría proporcionarnos una muestra del frijol que cosechó este año?

SURVEY ON ADOPTION OF IMPROVED BEAN VARIETIES IN THE DISTRICT OF GUADALUPE VICTORIA, DURANGO, MEXICO 2001

INIFAP-SAGARPA

BASIC INFORMATION

Farmer's Name ____________________ Questionnaire ID Number _______________

Locality ______________________________ Municipality __________________________

Enumerator's name _________________________ Date ____________________________

<u>CONSENT STATEMENT</u>
<u>(Before beginning the interview, read the following statement to the farmer)</u>

My name is** <u>Horacio Gonzalez</u>. **I am conducting a study of bean production in Mexico. I'd like to ask you some questions about your bean production activities. The information that you provide will be used to better understand farmers' bean production decisions, especially their choice of the varieties that they plant. The information that I collect from you and other bean farmers in the area will be used to complete my doctoral dissertation in the Department of Agricultural Economics at Michigan State University, USA.

This study is sponsored by INIFAP, in collaboration with the Bean/Cowpea Collaborative Research and Support Project (CRSP) at Michigan State University, East Lansing, Michigan, USA.

Your participation is <u>VOLUNTARY</u>. Your refusal to participate in or to withdraw from the study carries no penalty or loss of any benefits. The interview will take about 60 minutes to complete. You are free to <u>NOT ANSWER</u> any of the questions that I will ask you. However, I hope that you will agree to answer all of my questions, as your answers will help me to better understand the bean farming system in Durango and why farmers prefer different bean varieties. All of the information that you provide will be kept <u>CONFIDENTIAL</u>. This means that your answers to my questions will not be shown to anyone else. No one will know your answers except me and your identity will be protected in any report based on the data. Your privacy will be protected to the maximum extent allowable by law.

If you have any questions about this study, please contact Professor Richard Bernsten, Department of Agricultural Economics, Michigan State University, 211 E Agriculture Hall, East Lansing, MI or phone Professor Bernsten at (517) 355-3449. If you have any questions regarding your rights and role as a human subject of research, please contact Dr. David Wright, Michigan State University, 248 Administration Building, East Lansing, MI or phone Dr. Wright at (517) 355-2180.

I agree that my participation is voluntary and accept to be interviewed.

Farmer's signature ________________________________

I. LAND INVENTORY

First, I'd like to ask about each of the fields that you planted in 2001.

1.1 Including all fields how many crops did you plant in 2001?

1.2 Including all fields how many hectares did you plant to each crop?

1.3 How would you assess the quality of the soil of the fields [Good, Regular, Bad]?

1.4 What is the tenure status f or the fields [Ejido; Pequeña Propiedad; Aparceria]?

1.5 Which kind of seed did you use for each crop [Certified, Improved (noncertified), Landrace]?

1.1 Crop	1.2 Hectares	1.3 Soil quality	1.4 Tenure	1.5 Kind of seed
1 Beans				
2				
3				

Kind of seed : C = Cerified; M = Improved (noncertified); R = Landrace

II. ACCESS TO TECHNICAL INFORMATION

Next, I would like to ask you how you receive information regarding better ways to grow beans and the availability of new bean varieties.

2.1 Last year what technical advice did you receive to increase your bean yields? (Specify)

____

Last year you received information about new varieties from the following means:

2.2 Radio/TV .... (0-No, 1=Yes) _____

2.3 Newspaper .... (0=No, 1=Yes) _____

2.4 Extension brochure .... (0=No, 1=Yes) _____

2.5 SAGARPA .... (0=No, 1=Yes) _____

2.6 Insurance Company .... (0=No, 1=Yes) _____

2.7 The bank .... (0=No, 1=Yes) _____

2.8 Another farmer .... (0=No, 1=Yes) _____

2.9 Demonstration plots .... (0=No, 1=Yes) _____

2.10 INIFAP .... (0=No, 1=Yes) _____

2.11 PEAT/SINDER technicians .... (0=No, 1=Yes) _____

2.12 Other (specify) ____

INPUT USE (point out the ones that apply)

2.13 Fallowing (YES/NO) _______

2.14 Harrowing (YES/NO) _______

2.15 Planting date _____________

2.16 Fertilizer (YES/NO) ________

2.17 First weeding (YES/NO) _______

2.18 Hand weeding (YES/NO) _______

2.19 Second weeding (Y/N) _______

2.20 Insecticide (YES/NO) _______

III. BEAN VARIETIES PLANTED AND PRODUCTION COST

Next, I'd like to ask you about the bean varieties that you have planted during the past 5 years.

3.1 What bean varieties have you planted from 1997 to 2001 [Certified; Improved ; Landrace]?

3.2 Where did you obtain the seed you planted?

3.3 How much did you paid for the bean seed [MX$/kg]?

3.4 How many hectares did you plant to each variety?

3.5 What was the yield for each bean variety [kg/ha]?

Year	3.1 Variety name (C, M , R)	3.2 Where did you get the seed?	3.3 Price (MX$/kg)	3.4 Area (has)	3.5 Yield (Mt/ha)
2001	1				
	2				
	3				

(Continues)

(Continued)

Year	3.1 Variety name (C, M , R)	3.2 Where did you get the seed?	3.3 Price (MX$/kg)	3.4 Area (has)	3.5 Yield (Mt/ha)
2000	1				
	2				
	3				
1999	1				
	2				
	3				
1998	1				
	2				
	3				
1997	1				
	2				
	3				

Kind of seed: C = certified; M = Improved (noncertified); R = Landrace

3.6 Are you generally able to obtain a sufficient quantity of the seed of the bean variety that you wish to plant? .... (0=No, 1=Yes) _________

3.7 IF NO

What is the problem? (Specify) ____

3.8 How many of the last ten years have been bad years for bean production ______________

3.9 How many people do you occupy for bean production? Family L _____ Hired L _____

3.10 What was your production cost per hectare this year [2001]? ______________________

IV. CREDIT

Next, I would like to ask you about your access to credit.

4.1 During year 2001, did you receive any credit to finance your bean production activities?

.... (0=No, 1=Yes) _________

4.2 IF YES

From whom did you receive credit? (Specify) ____________________

4.3 How much credit did you receive [$/ha]? ____________________

4.4 For what did you use this credit? (Specify) ____________________

V. FARMING MACHINERY

Next, I would like to ask you about the machinery you use in growing beans.

5.1 Do you own a tractor? .... (0=No, 1=Yes) ________

5.2 IF NO

How do you get access to a tractor? (Specify) ____________________

5.3 Do you own a pileteadora? .... (0=No, 1=Yes) ________

VI. BEAN SALES

Next I would like to ask you about your bean sales.

6.1 How many Mt of each variety did you sell in 2000?

6.2 To whom did you sell each of these varieties?

6.3 What was the price that you received for each/variety [$/kg]?

6.4 Do you think that this is a good price for this variety?

6.5 IF NO

Why not?

Variety Name	6.1 Sales (Mt)	6.2 To whom did you sell?	6.3 Price (MX$/kg)	6.4 Is this a good price?	6.5 IF NO: Why not?
1					
2					
3					

6.6 How many members of your family have an off-farm employment (including you) _____

6.7 How many months they work a year? You ____ Wife _____ Other: a____ b____ c____

6.8 Usually what did you do with the chaff from your bean crop? (Specify) ______________

____

6.9 Do you believe that some varieties produce more chaff? .... (0=No, 1=Yes) _____

6.10 IF YES

Which varieties produce the most chaff? (Specify) ______________________________

____

VII. ASSESSMENT OF NEW BEAN VARIETIES

Next, I would like to ask your opinion about the bean varieties that INIFAP has released during the past 10 years, compared to traditional variety __________________ (Name of landrace)

How does the new compare to your preferred traditional variety, in terms of:

7.1 grain yield (kg/ha)?
7.2 market acceptance?
7.3 drought resistance?
7.4 pests resistance?
7.5 frosts evasion?
7.6 treshing problems?
7.7 disease resistance?
7.8 type of plant?
7.9 days to maturity?
7.10 consumption quality?

Scale: P = Worse I = Same M = Better N = No opinion/Don't know

Improved Variety	7.1 GY	7.2 MA	7.3 DR	7.4 PR	7.5 FR	7.6 TP	7.7 DR	7.8 KP	7.9 GP	7.10 CQ
1										
2										
3										

(IV = Pinto Villa, P.Mestizo, P.Bayacora, Negro Altiplano, Negro Sahuatoba, etc.)

VIII. PARTICIPATION IN GOVERNMENT PROGRAMS

8.1 For how many hectares did you receive the Procampo subsidy [MX$829/ha]? __________

8.2 How many kilos of certified seed did you receive from the KxK program? ____________

8.3 What variety did you get from KxK and what was the price? ______________ _____$/kg

8.4 Other government support [Pronasol?] (Specify) ________________________ _____$/ha

IX. SOCIOECONOMIC INFORMATION

Next I would like to ask you some questions about yourself.

9.1 How old are you? ____________________

9.2 Up to what grade did you study? ______________________

9.3 How many years have you planted beans? _______________________

9.4 Are you a member of a farmer association? Which one? ___________________________

9.5 IF YES: Has the association influenced your decision regarding which bean variety you planted? .... (0=No, 1=Yes) __________

9.6 IF YES: How? (Specify) ____

9.7 Usually how many tons of beans do you store before selling? _______________________

9.8 Usually how many months do you store the beans for sale? _________________________

X. TRANSPORTATION COSTS

10.1 What's the distance/time from your farm to the nearest city? ________km ________hrs

THANK YOU FOR YOUR ASSISTANCE!

A. Would you like to make any additional comment? ________________________________

____

B. Additional comments from the enumerator ______________________________________

____

C. Could you provide us a sample of the beans that you harvested this year?

Appendix B: Table 1. Bean area, Production and Yield in Mexico, 1990-2000.

Year	Planted Area Million ha	Harvest Area Million ha	Production Million Mt	Yield Kg/ha
1990	2.272	2.094	1.287	615
1991	2.199	1.989	1.379	693
1992	1.861	1.296	0.719	555
1993	2.151	1.874	1.288	687
1994	2.386	2.087	1.364	654
1995	2.354	2.040	1.271	623
1996	2.196	2.048	1.349	659
1997	2.320	1.615	0.965	598
1998	2.376	2.146	1.261	587
1999	2.394	1.695	1.081	638
2000	2.114	1.787	1.159	648
Average	2.238	1.879	1.193	632

Source: SAGAR (2000).

Appendix C: Table 2. Apparent Consumption of Beans in Mexico, 1980-2000.

Year	Production Mt	Imports Mt	Exports Mt	Apparent Consumption[a] Million Mt
1980	935,174	444,306	2,138	1.377
1981	1,331,287	482,126	2,006	1.811
1982	979,802	250,044	25,548	1.204
1983	1,285,171	145,848	55,851	1.375
1984	930,692	119,125	130,274	0.920
1985	911,908	178,921	122	1.091
1986	1,085,536	178,951	0	1.264
1987	1,023,734	39,470	69	1.063
1988	862,428	41,612	8,696	0.895
1989	593,436	110,370	1,178	0.703
1990	1,287,364	330,471	210	1.618
1991	1,378,519	30,080	420	1.408
1992	718,574	2,909	17,710	0.704
1993	1,287,573	7,571	7,309	1.288
1994	1,364,239	57,510	99,870	1.322
1995	1,270,915	26,062	82,872	1.214
1996	1,349,098	130,780	9,017	1.471
1997	965,056	90,161	7,256	1.048
1998	1,260,658	202,005	5,688	1.457
1999	1,080,631	128,028	8,446	1.200
2000	1,508,801	87,661	7,091	1.239

a. Apparent Consumption = Production plus imports minus exports.
Source: Computed with data from FAO (2002a) and SAGAR (2000).

Appendix D: Table 3. Real Producer Prices for Beans in Mexico, 1990-2000.

Year	Current Price[a] MX$/Mt	CPI (1994=100)	Real Price MX$/Mt
1990	1,988	60.12	3,307
1991	2,052	73.75	2,782
1992	2,266	85.18	2,660
1993	2,157	93.49	2,307
1994	1,901	100.00	1,901
1995	2,000	135.00	1,481
1996	3,790	181.41	2,089
1997	4,205	218.83	1,921
1998	5,154	253.68	2,032
1999	3,783	295.76	1,279
2000	4,403	323.83	1,360

a. Average price paid to growers in the bean regions.
Source: FAO (2002a).

Appendix E: ARTTP Regulations

The specific regulations of the ARTTP establish that (SAGARPA 2001a):

1) The Produce Foundations should make agreements with the COFUPRO and assign for that purpose up to 3% of the resources allocated to each state.
2) COFUPRO, in order to assist the Produce Foundations, should design a classification system for the projects.
3) COFUPRO and the Secretariat of Agriculture should establish a unique format for applications that should be distributed to the Produce Foundations for its utilization in all of the country.
4) The resources provided by the supports of the program can not be utilized for the acquisition of real estate properties.
5) In the case of projects for multiplying seed of new varieties or the utilization of that seed for emergency programs, the approval of the Secretariat of Agriculture (SAGAR) will be required.
6) The technical guides and procedure regulations issued by the Secretariat of Agriculture (SAGAR) will be submitted to the consideration of the COFUPRO.
7) The Produce Foundations in each state will contract every year an external technical audit that will be submitted to the Technical Committee of the Trust.
8) Produce Foundations will be granted, to for general operation expenditures, up to 3% of those authorized for the programs of the Alliance.

For the purpose of supporting the implementation of research projects or events at the national level, the Secretariat of Agriculture (SAGAR) could allocate budgetary resources to coordinate actions with the "Consejo Nacional de Ciencia y Tecnologia" (CONACYT) (National Council for Science and Technology), or with international organizations.

Appendix F: Strategy of INIFAP

INIFAP's strategy for achieving its objective includes the following principles (SAGARPA 2002):

Development of domestic research capacity. To achieve research of high quality, INIFAP is committed to developing the research capacity of scientist and technicians, and the skills of auxiliary personnel. To achieve that goal, the INIFAP has the support of the National Council of Science and Technology (CONACYT), which provides funding for formal training and education of the researchers. INIFAP is also committed to developing administrative and operative personnel, as well as the improving its physical infrastructure.

Recognition and use of farmers' empirical knowledge. INIFAP recognizes that farmers have developed technologies over many years that allow them to produce their food. These technologies are considered as the base for the development of future technologies. Therefore, high priority is given to documenting the empirical knowledge and practices of farmers, and collecting native genetic materials.

Rational exploitation of genetic materials. Exploitation of genetic materials of both native and species introduced and adapted to the country is of crucial importance to breeders. INIFAP scientists use the different sources of germoplasm to generate new improved plant varieties and animal species to meet the demand for food with the appropriate quality.

Realization of joint research. Given that there are other research institutions in the country and a diversity of international research centers, to avoid duplication and make a better use of scarce resources, the INIFAP seeks opportunities to implement joint research projects supported by collaboration agreements with private and public institutions at the national and international level.

Exchange of materials and information. INIFAP scientists participate in research international programs. Through those programs, the institute exchanges genetic material, scientific information, and scientists to take advantage of the scientific advances in the rest of the world. Agreements for scientific collaboration have been established with organizations like IRRI in Philippines, CIAT in Colombia, CIP en Peru, ICRISAT in India, and CIMMYT in Mexico.

Validation of research results. One INIFAP's important activities is testing and adjusting technological information produced by the different research programs. Through this process, technologies generated at the experiment stations are adapted to the specific conditions of the farmers and to the particular characteristics of regions.

Diffusion of research results. INIFAP promotes the speedy and effective diffusion of research results to: a) technicians and extensionists, b) research and academic institutions, c) agricultural services organizations, d) formal farmer organizations, e) individual farmers, and f) the general public. Diffusion is done via the Secretariat of Agriculture and other institutions of the agricultural sector, not directly to farmers.

Appendix G: Requirements for Eligibility of PEAT

To qualify to receive the benefits of PEAT, farmers must meet the following criteria (SAGARPA 2002):

Support is directed to individual farmers and their economic organizations that desire to incorporate technologies into their production systems, independent of land tenure, and farm no more than 20 hectares under rainfed conditions or the equivalent, as long as their plots are classified as high potential, medium potential, and low risk.

For hiring individual technicians or a technical office, farmers should voluntarily organize into groups for receiving technical assistance, with an area of 500 to 600 ha in basic crops or the equivalent in other crops. The group should include 80 to 120 farmers, according to the characteristics of the area, distribution of crops, and availability of roads.

The farmers should elect one farmer as representative of the group, and a group of technical assistance and diffusion should be integrated with early-adopter farmers to establish with them the demonstration plots for technology diffusion. A list with the names and addresses of these farmers should be submitted.

Other members of the group should receive technology diffusion and technical assistance for all the stages of the crop from planning to harvest and marketing.

Orientation about the programs and procedures to obtain the benefits of the programs of the Alliance for the Countryside should be provided to all group members, so that they can reduce their costs and improve the terms of exchange.

The group's applications will be evaluated by the "Comision de Desarrollo Rural" (Rural Development Commission" by using the criteria for competitive funding.

More weight should be given to supporting areas with less relative development where there are some contribution and co-responsibility of the partners, socially marginal groups, technological development, shift into the production of more productive crops, sustainable agriculture, diversification of production, generation of rural employment, and access to input and output markets.

Appendix H: Requirements to Apply for a Breeder's Patent

The requirements to apply for a breeder's patent are specified in the Vegetable Varieties Federal Law (SAGARPA 2002):

1) Breeder's application in official format.
2) Technical report containing the variety description in accordance with the SNICS normative guidelines, or following the International Union for the Vegetables Breeding Protection Procedures.
3) Rights payment receipt (for analyzing and executing the application and, if necessary, to recognize the priority right.
4) If required, legal document to demonstrate the representative's identity.

All documents should be submitted to SNICS' office. The fees to pay are detailed in the regulations established in the Vegetable Varieties Federal Law, which are updated and published periodically in the "Diario Oficial de la Federacion" (DOF) (Federation Official Diary).

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