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Maize Adoption, Biodiversity Conservation and Poverty in Mexico

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Dedicated to my lovable wife Mara Ruiz-Salazar
and
my wonderful and incredible son Sebastián Becerril-Ruiz
in gratitude for their support, sacrifices and time

It is also dedicated with all respect to my parents
Mrs Guillermina García-García & Mr Benjamín Becerril-Flores
and
my sisters and brothers
for their constant encouragement and support

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Summary

Maize production plays a key role in the livelihoods of many small-scale farm households in Mexico, although its productivity remains relatively low. It is known that improved germplasms have the essential attributes for enhancing maize productivity. However, after more than four decades of improved maize varieties' availability in Mexico, only one fourth of the total maize area was covered with improved varieties in 1996. Therefore, a considerable portion of the rural households cultivating maize still live in poverty. In addition, there is a general concern about the loss of maize genetic diversity among scientists, researchers and political institutions as Mexico is the center of origin and diversity for maize.

This study examines three related topics: households' improved germplasm adoption, conservation of maize genetic diversity and the impact of maize technology adoption on poverty alleviation in two of the poorest states of Mexico, i.e., Chiapas and Oaxaca, using cross-sectional survey data of 325 maize producers collected between October and December 2001. A binary probit model as well as a count data poisson model and propensity score matching is employed to estimate maize technology adoption, maize diversity conservation and the impact of maize adoption on poverty alleviation, respectively. Specifically, propensity score matching is employed to investigate existence of cause and effect relationship, i.e., whether adoption of improved maize varieties like hybrid or OPV reduces small-scale farmers' poverty.

The results reveal significant and positive impacts of improved germplasm adoption on per-capita expenditures (as a measure of poverty status). Particularly, maize hybrid in Chiapas, and creolized maize in Oaxaca were found to have a strong impact on poverty levels. The findings are quite informative as traditional economic analyses on the impact of maize adoption often focus on high yielding varieties, like maize hybrid, with little emphasis on intermediate maize varieties or varieties that are modified by farmers such as creolized maize. Furthermore, few studies assessed the impact of maize technology adoption as such. Therefore, this study sheds light on the discussion of whether maize adoption helps the poorest farmers or not. The analysis highlights the potential role of maize technology adoption in directly reducing poverty through enhancement of small-scale farmers' per capita expenditure. Therefore, this result strongly suggests that improved germplasm is an important mechanism to help rural households to get out of poverty. This reveals the need for the evaluation of a broader set of maize types for maize breeding programs.

Additional results indicate that technology development for agriculture under less favorable conditions has to be attended by breeding programs at international and national level, as well as in the domestic government policy agenda. Factors that influence a household's likelihood of conserving maize genetic diversity in the traditional crop system are analyzed using a count data poisson model. The results indicate that the households' socioeconomic constraints are characteristics that significantly motivate small-scale farmers to manage a portfolio of local maize varieties, beans and squash in the traditional *Milpa* system. Old age and indigenousness of the household head, number of purposes maize is used for, higher number of farm plots, farm plots with poor soil quality, and high dependence on human labor characterize households using the subsistence oriented farming system which owns and produces the wealth of local varieties in the study areas. Conversely, the empirical results from binary probit model provide several insights to understand farmers' maize adoption behavior. The results revealed that age of the head of the household, proportion of male family members aged between 15 -50 years, number of horse owned as a capital asset, farm size and land quality increases the likelihood of maize technology adoption. These findings have important implications for maize breeding programs as well as government policy programs targeting to eradicate poverty, food insecurity, and crop genetic erosion in centers of diversity like Mexico.

Zusammenfassung

Die Maisproduktion spielt in der Lebensweise vieler kleinbäuerlicher Haushalte in Mexico eine zentrale Rolle, obwohl die Produktivität relativ gering geblieben ist. Es ist bekannt, dass in verbessertem genetischem Material die wichtigen Eigenschaften zur Steigerung der Produktivität des Maisanbaus vorhanden sind. Nach mehr als vier Jahrzehnten der Verfügbarkeit verbesserter Sorten in Mexiko erfolgte der Anbau dieser Sorten 1996 jedoch nur auf einem Viertel der Fläche. Daher lebt ein erheblicher Anteil der ländlichen Haushalte, die Mais anbauen, weiterhin in Armut. Gleichzeitig besteht unter Wissenschaftlern sowie Forschungs- und politischen Institutionen eine generelle Besorgnis über den Verlust genetischer Vielfalt beim Mais, das Mexico das Ursprungsland des Mais und seiner Vielfalt ist.

Die vorliegende Arbeit untersucht drei miteinander verbundene Aspekte: Die Adoption verbesserter Sorten durch die Haushalte, Konservierung der genetischen Vielfalt des Mais und die Auswirkungen der Adoption der neuen Maissorten auf die Senkung der Armut in zwei der ärmsten Bundesstaaten Mexikos, Chiapas und Oaxaca. Die Untersuchung basiert auf eine Befragung von 325 Maisproduzenten aus dem Jahr 2001. Dabei kamen Probit- und Possionmodelle sowie das Propensity Score Matching zur Modellierung der Entscheidung über die Anwendung der neuen Maissorten, der Konservierung der Maisdiversität beziehungsweise der Effekte des Anbaus neuer Sorten auf die Armutssenkung zur Anwendung. Insbesondere dient das Propensity Score Matching der näheren Betrachtung einer Ursache und Wirkung Beziehung, das heißt, ob der Anbau neuer verbesserter Sorten die Armut der Kleinbauern reduzieren kann.

Die Ergebnisse zeigen signifikant positive Einflüsse der Adoption von verbesserten Maissorten auf die Pro-Kopf-Ausgaben als Maß der Armut. Insbesondere kann ein starker Einfluss des Anbaus von Maishybridsorten in Chiapas sowie des Anbaus verbesserter traditioneller Sorten in Oaxaca festgestellt werden. Dieses Ergebnis ist von besonderem Interesse, da traditionelle ökonomische Analysen der Adoption neuer Technologien im Maisanbau zumeist auf sehr ertragsreiche Sorten, wie Hybridsorten,

fokussieren und weniger auf nicht so sehr auf Sorten mit mittlerem Ertragsniveau, die von den Landwirten selbst weiterentwickelt wurden.

Bisher haben wenige Studien die Auswirkungen der Adoptionsentscheidung näher analysiert. Daher trägt diese Arbeit zur Diskussion, ob der Anbau neuer Maissorten den ärmsten Landwirten zu Gute kommt oder nicht, bei, in dem die mögliche Rolle der Adoption neuer Maissorten bei der direkten Reduzierung der Armut durch Steigerung der Pro-Kopf-Ausgaben von Kleinbauern analysiert wird. Die Ergebnisse weisen deutlich darauf hin, dass verbessertes genetisches Material im Maisanbau für ländliche Haushalte ein wichtiger Faktor zur Überwindung der Armut ist. Daraus ergibt sich die Notwendigkeit der Bewertung einer breiteren Auswahl von Sorten zum Einsatz in Maiszuchtprogrammen. Zusätzliche Ergebnisse legen nahe, dass die Entwicklung von Technologien für die Landwirtschaft in benachteiligten Gebieten von Zuchtprogrammen auf nationalem und internationalen Niveau sowie entsprechenden politischen Maßnahmen der jeweiligen Regierung begleitet werden sollten.

Die Ergebnisse des Poisson Modells zur Analyse der Wahrscheinlichkeit, dass ein Haushalt zur Konservierung der genetischen Vielfalt durch traditionelle Anbausysteme beiträgt, deuten an, dass sozioökonomische Beschränkungen Kleinbauern motivieren, mehrere lokale Maissorten anzubauen und diese mit Bohnen und Kürbis zum traditionellen *Milpa* Produktionssystem zu kombinieren. So sind unter den persönlichen Charakteristika ein hohes Alter des Haushaltsvorstandes und Zugehörigkeit zur eingeborenen Bevölkerung zu nennen. Weiterhin charakterisieren eine größere Anzahl von Verwendungen des Mais, eine größere Anzahl an bewirtschafteten Flächen, Flächen mit schlechter Bodenqualität sowie eine hohe Abhängigkeit vom Faktor Arbeit das auf Subsistenz ausgerichtete Produktionssystem, dass eine Vielfalt von Maissorten in den untersuchten Regionen beinhaltet und auch hervorbringt.

Die aus dieser Untersuchung hervorgegangen Ergebnisse beinhalten wichtige Implikationen für Zuchtprogramme beim Mais sowie auch politische Programme der Regierung die auf die Armutsbekämpfung, unsichere Nahrungsversorgung und die Abnahme der genetischen Vielfalt der Getreidearten in Zentren der Vielfalt wie Mexico abzielen.

List of acronyms and abbreviations

ASERCA	Aid and Services to Agricultural Commercialization.
ATT	Average Treatment Effect on the Treated.
CBD	Convention on Biological Diversity.
CGI	Crop Genetic Improvement.
CGIAR	Consultative Group on International Agricultural Research.
CIMMYT	International Maize and Wheat Improvement Centre.
CONAPO	National Council of Population.
CONASUPO	National Company for the People Subsistence.
CTMP	Comité Técnico para la Medición de la Pobreza.
FAO	Food and Agricultural Organization of the United Nations.
GDP	Gross Domestic Product.
HYV	High Yielding Varieties.
IAEG	Impact Assessment and Evaluation Group.
IARC	International Agricultural Research Centre.
IFPRI	International Food Policy Research Institute.
IMPACT	International Model for Policy Analysis of Agricultural Commodities and Trade.
INEGI	Instituto Nacional de Estadística, Geografía e Informática.
INIFAP	National Forestry, Agricultural and Livestock Research Institute.
KBM	Kernel Based Matching.
LDC	Less Developed Countries.
MT	Maize Type.
MV	Modern Varieties.
NAFTA	North America Free Trade Agreement.
NARS	National Agricultural Research System(s).
NGO	No Governmental Organization.
NNM	Nears Neighbor Matching.
OPV	Opened Pollinated Variety.
PROCAMPO	Program of Direct Countryside Support.

PROGRESA	Programa de Educación, Salud y Alimentación.
PRONASE	National Seed Production Agency.
PSM	Propensity Score Matching.
R&D	Research and Development.
SAGARPA	Livestock, Rural Development, Fisheries and Food Industry.
SEMARNAT	Ministry of the Environment and Natural Resources.
SEP	Secretaría de Ecuación Pública.
SIAP	Servicio de Información Agroalimentaria y Pesquera.
SPIA	Standing Panel on Impact Assessment.
TV	Traditional Variety.
USA	United States of America.
USAID	United States Agency for International Development.
USDA	United States Department of Agriculture.

Chapter 1

Introduction

1.1 Background

Maize is Mexico's most important crop (nutritionally, economically, ecologically, and politically) and is cultivated throughout the country in a wide range of production environments. From the nutritional point of view, maize is the main staple food and principal source of calorie intake for most of the population. Mexican inhabitants consume roughly two-thirds of the maize produced, principally in the form of "*tortillas*" (thin round cakes made from ground grain and water, cooked on a heated clay or metal surface), which contributes to approximately two-thirds of the calorie intake and about one-third of the protein in an average Mexican diet (Aquino, 1998). Furthermore, there are more than 600 different food preparations involving maize, many of which require different types of maize (SEP, 2002). The annual per capita maize consumption is roughly 127 kg (Morris, 1998). Not unexpectedly, considering the central role maize plays in human diets, Mexican consumers readily distinguish among a wide range of maize varieties on the basis of physical attributes such as appearance, texture, taste, smell, processing quality, cooking quality, and storage quality. The consumers strongly prefer white-grained varieties (SEP, 2002).

Morris (1998) argues that no other cereal can be used in as many ways as maize. Virtually every part of the maize plant has economic value. The grain can be consumed as human food, fermented to produce a wide range of foods and beverages, fed to livestock, and used as an industrial input in the production of starch, oil, sugar, protein, cellulose, and ethyl alcohol. The leaves, stalks, and tassels can be fed to livestock, either green (in the form of fodder or silage or dried in the form of stover). Even the roots can be used for mulching, incorporated into the soil to improve the physical structure, or dried and burned for fuel. The total country's maize consumption in 2005 was approximately 25 million tons. Of the 25 million tons, 11 millions tons consisted of white maize which was processed in the milling industry as well as in rural households (for production of flour and dough to make *tortillas*). About 13 million tons of yellow maize was processed in the feed industry (for production of balanced livestock feeds) and other specialized extractive industries (for production of starch, oil, and other industrial products). The remaining one million ton was distributed in cereals and snacks industry and rural household poultry and minor-animal feeds (Moody and Garcia-Leon, 2007).

From the economic point of view, the Mexican government has taken a number of initiatives to increase the productivity of maize-based cropping systems and to improve food-security and welfare of the rural population. Improved maize varieties have been available in Mexico for more than 40 years, but adoption of these varieties has been limited. Despite repeated government programs to promote the use of improved seeds, only about 25% of the total maize area (7.9 million ha) in the country was planted with improved varieties[1] in 1996. Most of this area is located in the commercial production zones of central and northwestern Mexico (Morris and López-Pereira, 1999, page: 35).

In the period between 1996 to 2005 Mexico was the fourth-largest maize producing country with 3% of the global maize production after the United States of America (USA) with 40%, China with 19%, and Brazil with 6% (SIAP, 2007). Annual production of maize in Mexico exceeds 19 million tons. In the period between 1996 and 2005 production grew at an average annual rate of 2%. Since the mid-1970s, growth in demand for maize in Mexico has consistently exceeded growth in supply, contributing to a widening deficit that has been overcome only with the help of imports. Currently, about 95% of maize imports originated from the USA, whose status as the low-cost supplier has traditionally been ensured by its geographic proximity to Mexico (Aquino, 1998; Dyer and Yunez-Naude, 2003; SIAP, 2007). Maize production generates 21% of total agricultural production value. The agricultural sector (agriculture, forestry, and fishing) contributed 6% to the Gross Domestic Product (GDP) in 2003 (INEGI, 2006).

These aggregate production statistics conceal considerable microlevel variability in production environments, farming systems, and cropping patterns. Producers who differ

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[1] 21% of the total area planted with maize corresponds to maize hybrid varieties, and 4% to improved OPVs.

in their resource endowments, technical knowledge, and crop management practices grow maize in Mexico in a wide range of agroclimatic diverse environments[2]. At one extreme, small-scale semi-subsistence producers grow maize primarily as a food crop with most of these farmers planting local or landraces varieties with low yield performance, high stability, and moderate resistance to local pests and diseases. Small-scale farmers are concentrated in the southern and central areas of the country, where rain-fed agriculture predominates. According to Morris and López-Pereira (1999) most of the maize production systems are characterized by their small-scale operations and their heavy reliance on animal traction and especially human labor. Maize is often grown in association with beans, squash, peppers, cassava, and other food crops destined for home consumption, usually known as intercrop *Milpa*[3] system and many farmers use little or no chemical fertilizer or pesticides. At the other extreme, large-scale farmers are concentrated in the irrigated[4] tracts of the central highlands and northern plains. Between these two extremes lie many intermediate types of farmers (Aquino, 1998).

A Mize production represents the primary source of income for millions of rural households. However, the productivity of Mexico's maize-based cropping system remains low by global standards, according to Morris and López-Pereira (1999) and Morris (1998). The yield in tons per hectare (t/ha) in 1995-97 was roughly 2.3[5] tons while Argentina, Brazil, Chile, China yields averaged 4.35, 2.55, 8.49 and 5.0 tons, respectively. Morris (1998) argues that with good management, commercial maize grain yields often reach 10 t/ha or more in favorable production environments such as the "corn belts" of the US and Western Europe. In contrast, subsistence farmers in marginal areas in Central America, sub-Saharan Africa, and Asia frequently harvest 0.5 t/ha or less grain from their maize plots. The variability in yields can be attributed to

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[2] Brush and Chauvet (2004) describe Mexico as a country with intermediate development and with tremendous heterogeneity and diversity in terms of physical environments, biological species, crops, cultures and types of agricultural production. They argue that there are different types of farmers with different cultivation practices and objectives.

[3] The Milpa-inter-crop system is a traditional Maize field intercropped with beans and squash.

[4] Dyer and Yunez-Naude (2003) point out that irrigated maize is mainly destined for the market, while a large proportion of rain-fed maize is for self-consumption.

[5] Corresponds to National yield average in 1995-97.

environmental, technological, and institutional factors that determine the physical potential of the crop. Consequently, a considerable portion of the rural households that cultivate maize still lives in poverty[6]. The *Comite Técnico para la Medición de la Pobreza* [CTMP] reported that in 2000 almost 28% of the rural households were considered extremely poor, living below the poverty line of approximately US$ 53 per-capita/month (CTMP, 2002). Levy and Wijnbergen (1992) argue that many small-scale farmers, or subsistence farmers, have plots of very poor quality, and maize production is directly associated with rural poverty.

From the ecological point of view, Mexico is within the primary region of maize diversity with a long history of co-evolution between maize and Meso-America's human populations (Bellon and Brush, 1994). Mexico is the center of maize origin. Archaeological and botanical evidence suggests that maize originated in southern Mexico or northern Guatemala between 6,000 and 7,000 years ago (SEP, 2002). To preserve crop diversity, policy makers and conservationists have to deal with issues of crop diversity that include valuation, measurement, property rights (Wale-Zegeye, 2004), and the relationship between poverty and diversity. Another concern is the potential *trade-off* between crop diversity and diffusion of improved crops as well as market development. Mexican maize is, among other crop genetic resources, the raw material for crop breeding and source of continuing advances in yield, pest resistance, and quality improvement (Bellon and Taylor, 1993; Pandey, 1998; van Dusen, 2000). Pandey (1998) argues that the germplasm used in maize breeding programs comes form a wide range of sources, including maize gene banks, the seed stores and breeding nurseries of public research institutes and private seed companies, commercial cultivars, and farmers' fields.

Genetic erosion has been documented in the cradle areas of crop domestication, where the loss of traditional cultivars accompanies the specialization and intensification that comes with the introduction and dissemination of modern, high-yielding varieties, for instance, the traditional potatoes in Andes-Peru (Brush et al., 1992; Brush, 1995). In Mexico since the signing of North American Free Trade Agreement [NAFTA] in 1994,

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[6] Dyer (2002) findings show that 94% of the households in *Sierra Norte de Puebla* produce less than their yearly consumption of maize, and 67% produce less than 25% of their maize consumption.

these concerns have increased due to imports of maize seed and grains from the USA. Boyce (1996) and Brush (1998) were the first to realize that liberalization of the maize sector would endanger Mexican maize landraces. Other government initiatives (such as the 1992 Land Reform) also imperiled *in-situ* conservation of maize (Dyer and Yunez-Naude, 2003). Evidence on dissemination and introgression of maize transgenic into the landraces have also been found in Oaxaca in 2000 by Quist and Chapela (2001).

From the agricultural policy point of view, in the last two decades the Mexican government has taken several reforms destined to reduce its involvement in the maize-production sector by introducing economic liberalization and integration into the global market. NAFTA put an end to barriers to exports of maize to Canada and the USA. Maize seed imports were completely liberalized at the start of NAFTA, but other maize–grains–were subject to a gradual liberalization scheme that will end in 2008 (Dyer and Yunez-Naude, 2003). The dismantling of the National Company for the People Subsistence (*Compañía Nacional de Subsistencias Populares* [CONASUPO]) and its disappearance in 1999 and subsequent closure put an end to guaranteed producer prices and where the government abolished purchases of maize (both domestic and imports) and its commercialization. It also put an end to subsidies to consumers of *tortilla* (Yunez-Naude, 2003).

In 1991 a new government agency, Aid and Services to Agricultural Commercialization (*Apoyos y Servicios a la Comercialización Agropecuaria* [ASERCA]) was created to take the place of direct government involvement through CONASUPO. ASERCA operates a different price program where producers sell their crops to industry at the international prices[7], and the government pays them the difference with an accorded price. At the beginning ASERCA dealt only with wheat and sorghum, the program incorporated maize in 1997. In 1993/1994, Program of Direct Countryside Support (*Programa de apoyos directos al Campo* [PROCAMPO]) was created as a transitional program: it is scheduled to conclude in 2008, when free trade is achieved. PROCAMPO substituted previous price supports. It consists of an income transfer to landowners who grow or recently grew barley, beans, maize, cotton, rice, sorghum, soybean, safflower,

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[7] Prices were set at the average international price based on the Chicago Commodity Exchange, plus transport costs to Mexican ports and operating (storage, transport, financial) costs.

and wheat. PROCAMPO's main goal is helping domestic producers of staples face competition from the USA and Canada, or turn to more competitive crops. In 1994 Alliance for the Countryside (*Alianza para el Campo*) was created, its main purpose is to increase agricultural output, capitalize producers, and promote agricultural efficiency through crop substitution (fruit and vegetables for staples) wherever there was a competitive advantage (Dyer and Yunez-Naude, 2003). *Alianza* includes PROCAMPO as well as other programs. As regards maize, one of the programs is "*Kilo por Kilo*", which provides producers with modern maize varieties in exchange for own seed.

Another of the closed government's offices was the National Seed Production Agency (*Productora Nacional de Semillas* [PRONASE]). PRONASE was created in 1961 to oversee the production, conditioning, and distribution of improved seed varieties in accordance with the plans and programs of the Ministry of Agriculture. From 1961 to 1991 production of certified maize seed was exclusively in the hands of PRONASE[8] (Aquino, 1998).

PRONASE played a key role on seed technology transfer, because this agency was a public organization, it does not have to generate returns to investors' capital. The explicit objective of PRONASE was to provide seed for low-income farmers. Consequently, PRONASE's seed prices were set at a level designed to recover only its operating costs. According to Aquino (1998) the prices of PRONASE seed were relatively low because this public agency does not have to recover any research costs through seed sales. The research costs were incurred by INIFAP, and it was supported directly by the government. Also, the PRONASE's prices were relatively low because this agency does not invest heavily in packaging and in promotional activities.

At the time of collecting data for this thesis, the government program of improved seed exchange and distribution–*Kilo por Kilo*–was ongoing. Government agencies delivered

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[8] PRONASE distributes the improved germplasm produced by National Institute of Forestry, Agriculture, and Livestock Research (*Instituto Nacional de Investigaciones Forestales y Agropecuarias* [INIFAP]). At the same time, the INIFAP maize-breeding program benefits from International Maize and Wheat Improvement Center (CIMMYT). That is, INIFAP operate under a national mandate of improvement, and CIMMYT has the global mandate of maize improvement.

certified seed to farmers in exchange for an equal quantity of their current seed (usually seed of local landrace or creolized). Alternatively, farmers can pay for certified seed using ordinary grain value at prevailing market prices. The *Kilo por Kilo* program was aimed primarily at small-scale farmers (defined as those who plant 20 ha or less) located in high production potential zones.

Lastly, Dyer and Yunez-Naude (2003) argued that the outcomes of NAFTA and domestic reforms a decade ago, include: (1) Maize imports would rise following reductions in tariffs and other barriers. (2) Mexican farmers would have to compete with foreign farmers. (3) Competition would results in greater efficiency and land productivity in maize. (4) This would trigger: (a) a drop in domestic prices of maize, (b) a decrease in the domestic supply of maize, and (c) a loss in maize diversity. (5) increased migration out of rural areas, and (6) consolidation of land into larger production units.

1.2 Problem setting and motivation

There is a large body of literature about maize technology adoption, maize biodiversity conservation and the evaluation of the effects of technology adoption on poverty alleviation. However there is no evidence of works that have analyzed the three aspects together. These three issues are a matter of concern for sustainable agricultural development in Mexico. Individual works on maize technology adoption have utilized dichotomy of variables (such as modern *versus* traditional technology), focusing on single maize type (e.g., hybrid) (Doss, 2003), and few works on maize technology adoption have included recent domestic agricultural reform (PROCAMPO and *Kilo por Kilo*) as well NAFTA impacts (emigration) in Mexico (Aquino, 1998). Regarding crop genetic conservation few works have taken into account poverty (e.g., Smale (2006), van Dusen and Taylor (2005), Wale-Zegeye (2004), Dyer and Yunez-Naude (2003), Brush and Meng (1998), Brush (1995). Concerning the evaluation of the effects of agricultural technology adoption on poverty alleviation, a few works have been constructed a counterfactual scenario, i.e., taking into account before and after technology adoption Kerr and Kolavalli (1999); Evenson and Gollin (2003); Adato and Meinzen-Dick (2007).

This study aims at filling this gap in the literature by analyzing three aspects: first, the factors that contribute to improved germplasm adoption; second, the factors that influence maize landraces, beans and squash conservation; and third assess the *causal-effect* of improved germplasm adoption on poverty alleviation, in rural areas in two of the poorest Mexican states, Chiapas and Oaxaca.

1.3 Objectives and hypotheses

The overall objective of this study is to assess the factors that influence small-scale farmers' maize technology adoption and which aspects contribute to farm household's maize biodiversity conservation. As well analyze the *causal-effect* of technology adoption on poverty in 325 farmer households in southwestern Mexico.

- Analyze the determinants of maize technology adoption.

- Study the factors of maize diversity conservation.

- Assess the relationship between technological change in maize production and poverty alleviation.

Three related hypotheses are analyzed:

(1) The persistence of maize production on small-scale farmers' fields is explained by socio-economic importance of maize for the households' livelihood. Only small-scale farmers with less socioeconomic constraints (e.g., family labor availability, capital assets, soil quality, and link to the market–distance–) are able to adopt modern germplasm. Remittances play a key role in eliminating the cash constraint as well.

(2) The economic crisis in 1994/1996, the Mexican economy integration into the global market (NAFTA), the internal drop in maize prices, and domestic agricultural reforms forces many small-scale farmers back into subsistence agriculture, maize landraces played a key role offering to small-scale farmers the lowest price of maize seed input, consequently poor farmers keep maize diversity (number of landraces) and minor crops like beans and squash into the

traditional *Milpa* system in order to ensure their food livelihood. Paradoxically, remittances threaten maize biodiversity conservation.

(3) Lastly, improved germplasm adoption (e.g., maize hybrid, OPV or creolized varieties) contributes directly to poverty alleviation through enhancement of small-scale farmers' per-capita expenditure.

1.4 Significance of the study

Few economic studies have attempted to investigate these three issues of adoption, conservation and poverty alleviation and their effects on household livelihoods. These three issues are matter of concern for agricultural sustainable development in Mexico.

The information from this study is hoped to contribute towards design of appropriate and demand-led maize breeding programs benefiting maize breeders, policy makers, maize farmers producers, researchers and non-government organizations while also building up on the existing body of knowledge.

1.5 Concepts and definitions of key terms

The following are the key concepts, definitions, and approaches used in this study.

- *Innovation*: Sunding and Zilberman (2001) define innovation as new methods, customs, or devices used to perform new tasks. They also distinguish several categories of innovations: innovations that are "embodied" in capital goods or products (such as tractors, fertilizers and seeds) and those that are "disembodied" (basically knowledge of improved methods). Furthermore they suggest that the classification of innovations according to form is useful for considering policy questions and understanding the forces behind the generation and adoption of innovations. Categories in this classification include mechanical innovations (tractors), biological innovations (new seed varieties), chemical innovations (fertilizers and pesticides), agronomic innovations (new management practices), biotechnological innovations, and informational innovations that rely mainly on computer technologies.

- *Maize innovation*: in this dissertation refers to the development of modern maize varieties such as maize hybrid, opened pollinated varieties [OPV], or maize transgenic, these are innovations that represent the embodiment of scientific knowledge in corn seed (Antle and Mcguckin, 1993).

- *Maize Hybrid*: the term hybrid refers to any plant produced from genetically distinct parents. In maize, the number and genetic composition of parents can differ enormously. In general, if the degree of genetic uniformity in the composition of a hybrid increases (i.e., the greater the degree of inbreeding used in developing the parent lines), the better its agronomic performance when grown under commercial production conditions. For simplicity's sake, a hybrid can be defined as the result of crossing two or more inbred lines. If hybrid seed is replanted, it will not be as productive as the original seed. Therefore, the seed has to be purchased every season to maintain high productivity (Pandey, 1998).

- *Maize OPV*: Opened Pollinated Varieties [OPV] are populations that breeders have selected for a very specific set of traits. Generally speaking, the components used to develop an OPV must meet local production and consumption requirements (high yield, desired maturity and height, resistance to or at least tolerance to prevalent diseases and insects, resistance to lodging, and similar factors). The OPV seed can be replanted usually up to three years without major drops in yield; seed can be purchased once every three years (Pandey, 1998; Bellon et al., 2006).

- *Maize Creolized*: "*Acriollada*" (translated here as creolized) derives from the work "*criollo*" which means local variety or landrace to farmers; it can loosely be translated to mean "becoming a *criollo*". In this dissertation, creolized varieties are defined as originally improved varieties that have been under farmer management for several generations (Bellon et al., 2006).

- *Maize Landrace*: refers to a locally grown maize population, the result of farmer selection and management over many generations (Bellon et al., 2006).

- *Biotechnology* refers to the manipulation of living organisms to alter their characteristics, use them as a component in a larger production process, and produce a desired product (Hoisington et al., 1998).

- *Transgenic* crops development differs from conventional breeding in three ways. First, transgenic crops use material from distant and unrelated gene pools. Second, a novel method of gene insertion is involved in creating transgenic crops. Third, there is a tendency for this type of crop development to be done privately and as intellectually property rather than by public breeding and as public good (Brush and Chauvet, 2004).

- *Introgression*: is the introduction of a limited number of genes from a donor parent through hybridization followed by repeated hybridizations to the recipient parent (the introgression parent).

- *Hybridization*: is the crossing of two individuals.

- *Seed recycling*: Saving seed from one season to the next is an almost universal practice among small-scale Mexican farmers. It is their main source of seed. Farmers usually follow strict procedure to select seed to retain for the next season. Farmers save seed not only of landraces but also of improved varieties (open pollinated or hybrids) (Morris et al., 1999; Berthaud and Gepts, 2004; Bellon et al., 2006).

- *Seed flows*: Small-scale farmers commonly acquire seed from other farmers or sources within or outside the community for several reasons, including experimentation, starting to farm, and lack of sufficient seeds (ibid.).

- *Food security*: is defined as an appropriate and sustainable equilibrium between self-sufficiency, employment and income generation, and natural resource conservation (Brush and Chauvet, 2004).

- *Adoption*: adoption in the context of technology research is the application or use of a technology or innovation (as a process or an object) by an individual or groups of individuals (Gerber, 2004).

- *Adoption in the context of maize production*: is defined as the use of specific maize type on farmers' fields.

- *Diffusion*: diffusion is the process by which an innovation is communicated through certain channels over time among the members of a social system. It is a special type of communication, because the messages are concerned with new ideas. Diffusion can be interpreted as aggregate adoption. As with adoption, there may be several indicators of diffusion of a specific technology. One measure of diffusion may be the percentage of the farming population that adopts new innovations. Another is the land share in total land on which innovations can be utilized (Feder et al., 1985).

- *In-situ*: in-situ means in place of origin, source or on farm (Smale, 2006).

- *E*x-*situ*: means off-farm where they are managed by plant breeders or gene banks (Smale, 2006)

- *In-situ conservation*: or on farm conservation. Implies the choice by farmers to continue cultivating biologically diverse crops and varieties in their communities in the agricultural ecosystems where the crops have evolved historically through processes of human and natural selection (Smale, 2006).

- *Milpa*: is a multi crop activity based on maize, often in combination with beans, squash and other edible herbs (Dyer and Yunez-Naude, 2003).

- *Poverty*: generally refers to a state in which one is unable to obtain basic necessities required to sustain a minimally adequate standard of living (Abdulai and Tietje, 2007). In this research, poor farmers are considers who live under the food-poverty line, i.e., farmers that expend less than the cost of food basket per-capita per month.

- *Livelihood*: comprise the capabilities, assets and activities required for a means of living (Kerr and Kolavalli, 1999).

- *Food-poverty line*: refers to the impossibility obtain a food-basket needed for adequate nutrition, given the consumption patterns of Mexicans, using all available resources (CTMP, 2002).

1.6 Organization of the thesis

The starting point of the thesis was to integrate economic analyses with research from four different topics in chapter 1: the value of maize nutrition, the economic importance of maize production, the matter of concern about lost maize genetic diversity, and a sketch of the last domestic policy reforms in Mexico. Chapter 2 presents a review of agricultural adoption theory, crop genetic conservation and the contribution of agricultural technology on poverty alleviation. In chapter 3, a theoretical model is presented in which a household's decision to adopt a new maize variety, to plant a *Milpa* is linked to household, farm and government programs characteristics variables.

Chapter 4 describes the process of villages selection and data collection, as well as statistical description of the basic households' characteristics, particularly land and area planted with maize. The empirical methodology and econometric specification are described in Chapter 5, the binary *Probit* regression, as well as the count *Poisson* models are introduced. The propensity score matching specification as well as nearest neighbor matching and kernel based matching methods are introduced.

The results from the regressions of household level adoption, diversity conservation and the *causal-effect* of maize technology adoption on poverty alleviation are presented in chapter 6. Finally, in chapter 7, concluding remarks are presented on the links between maize adoption and poverty, and biodiversity conservation. Possible directions for future research are finally discussed.

Chapter 2
Literature review

Given the three major objectives and their inter-linkage in this dissertation, this chapter has three sections on literature review. Section 2.1 offers a literature review on agricultural technology adoption. Section 2.2 portrays the importance crop genetic resources conservation with a particular focus on maize diversity. Section 2.3 presents a brief discussion of the impact of agricultural technology adoption on poverty alleviation.

2.1 Agricultural technology adoption

There is general consensus among economists that technology change must play a key role in the agricultural development of less developed countries [LDC] because the economic base of most LDCs is generally dominated by agriculture and the livelihood of the majority of their inhabitants depends on farm output (Rauniyar and Goode, 1992). Increased agricultural output is needed both for domestic consumption and for export. But small-scale farmers are not adopting the new mechanical and biological technology that would lead to increased yields. Consequently, social scientists have generated substantial body of literature designed to identify the social and economic factors that are associated with technology adoption. The works of Feder, Just and Zilberman (1985) and Feder and Umali (1993) form milestones in agricultural technology adoption literature.

In this huge body of literature, some economists tend to distinguish between agricultural technology adoption paradigms. According to Adesina and Zinnah (1993) two major groups of paradigms for explaining adoption decisions are: (1) adoption perception and (2) economic constraints. This dissertation is based on economic constraint paradigm. A sketch of each paradigm is presented below.

2.1.1 Adoption perception

Adesina and Zinnah (1993) point out that adoption perception paradigm examines the contexts in which different technologies supply valued traits to farmers and influence their adoption decisions (e.g., Smale et al., 2001; Hintze et al., 2003; Edmeades et al., 2004; Bellon et al., 2006). In this literature, adoption decisions are modeled based on the principle that households derive utility from the technology's traits or attributes, rather than from the technology itself.

Rogers (2003) proposes that five technology attributes influence its adoption. The first attribute, relative advantage, is the degree to which an innovation surpasses current practices. The literature identifies key dimensions of relative advantage to include "degree of economic profitability, low initial costs, decrease in discomfort, social prestige, saving in time and effort and immediacy of the reward." The second attribute, compatibility, is the perceived consistency of the innovation with the established values, needs and experiences of potential adopters. If a new technology does not meet the adopters' needs, it will probably not be adopted. The adoption of an incompatible innovation often requires prior adoption of a new system of values, which is a relatively slow process. Another attribute of innovation is complexity. This is the degree to which an innovation is viewed as difficult to understand and use. The more complex an idea is perceived to be, the longer it will take for it to be adopted. The fourth attribute of innovation is trialability. This is the degree to which an idea can be tested on a limited basis. An innovation that is trialable represents less uncertainty to the individual who is considering it for adoption. Trialability reduces uncertainty and greatly increases the rate of adoption. The last attribute, observability, is the degree to which the results of an idea are visible. The easier it is for people to actually see the results of an innovation, the faster they will accept the idea.

2.1.2 Economic constraints

This paradigm contends that economic constraints reflected in asymmetrical distribution patterns of resource endowments are the major determinants of observed adoption behavior. For instance: age, education, lack of access to capital, farm size, land soil quality, credit, and labor availability could significantly constrain adoption decisions (Feder et al., 1985; Adesina and Zinnah, 1993; Feder and Umali, 1993).

According to Gerber (2004) who argues that the central assumption of this model, also known as the factor endowment model, is that the distribution of resources endowments among potential users in a country or region determines the pattern of adoption of a technological innovation. This model assumes market prices and the importance of prices policies in the adoption decision. In this paradigm, farmers are assumed to behave as utility maximizers. They seek to optimize their factor input and choice of enterprise according to the assumptions of the neo-classical framework. Farmers will only introduce a new product if its utility, which is defined in terms of profits, is higher that "traditional" product (Figure 2.1).

In this model, economic constraints are the major determinants of observed adoption behavior (Adesina and Zinnah, 1993). However, advocates of the constraint approach assume that the profitability of a technology is not equal for all its potential users and that farmers' perceptions of a technology are influenced by different factors such as: (a) the conditions under which farmers operate, (b) the characteristics of the farmers, and (c) the characteristics of the farmers themselves (Gerber, 2004).

Since these factors vary from one farmer to another, the perceived profitability of the new technology will also differ. The principal factors that influence constraints and profitability perception are described below and are taken from Gerber (2004).

(a) The conditions under which farmers operate. Gerber (2004) discussed three major types of farming conditions that influence farmers' perceptions regarding the profitability of technologies (Figure 2.1). These are the production environment, the infrastructure in the region and the functioning of markets. The probability of using a technology is influenced by biological, physical and climatic production conditions, or farming circumstances, through their influence on the nature of the production functions of a commodity for a given input technology. Differences in these variables result in a varying optimum use of inputs for the same technology depending on the location. Consequently, the outer-board production function is not the same for all farmers and technically efficient production for a community differs accordingly. This leads to differences in the intensity of input use, such as pesticides against tick-borne diseases for improved cattle.

Differences in infrastructure relating to input supply, information provision and transport facilities can influence the perception of the utility of a new technology because they affect costs and the risk associated with adoption (Gerber, 2004). For example, in regions where input supply (concentrates or minerals) is poor and/or irregular, farmers may hesitate to adopt the new technology due to the high risk and transactions costs this involves. An unreliable supply of inputs may result in sub-optimum use of the innovation (Feder et al., 1985). For example, if an improved cow does not receive a regular ration of concentrates of minerals, this has a direct influence on the animal's milk yield and also on its health. In regions where a regular supply of inputs cannot be guaranteed, farmers will be deterred from adopting the new technology.

Poor information may also have a negative influence on the probability that a new technology will be adopted. If there are no services to provide technical information on the new technology, farmers will remain uninformed, or will not have enough information on which to base their adoption decision. Lack of information results in great uncertainty about a new technology and can cause farmers to reject it as too risky. In addition, they are unable to itemize the advantages of the new technology correctly. It is therefore obvious that farmers in regions where they have access to information sources, such as extension workers or no governmental organizations (NGOs), are more willing to adopt than farmers in isolated areas.

Transport infrastructure influences the price of products and production factors. A greater distance to market outlets influences both the input and output prices of a product. Farmers will tend to specialize in agricultural products according to their respective transport costs. The intensity of land-use and the choice and intensity of input application will be higher in regions near markets and with better infrastructure since higher product prices and lower factor costs permit higher input use (Gerber, 2004).

The functioning of markets also has an effect on the access to, and cost of the different production factors, such as capital or labor. For example, access to capital is an important variable determining the adoption decision. The adoption of lumpy technology, such as improved cattle, requiring high initial investment, is certainly restricted by the lack of credit. In particular, small-scale farmers find it difficult to save the large sum required for the initial investment and will therefore be more likely to abide by the traditional method or not to adopt the new one. Small-scale farmers usually obtain credit on the informal capital markets (local moneylenders, traders or landowners) where rates of interest tend to be higher than those charged on the formal capital markets (Gerber, 2004). Given these imperfect capital markets, farmers face different factor prices that lead to differences in the choice of technologies.

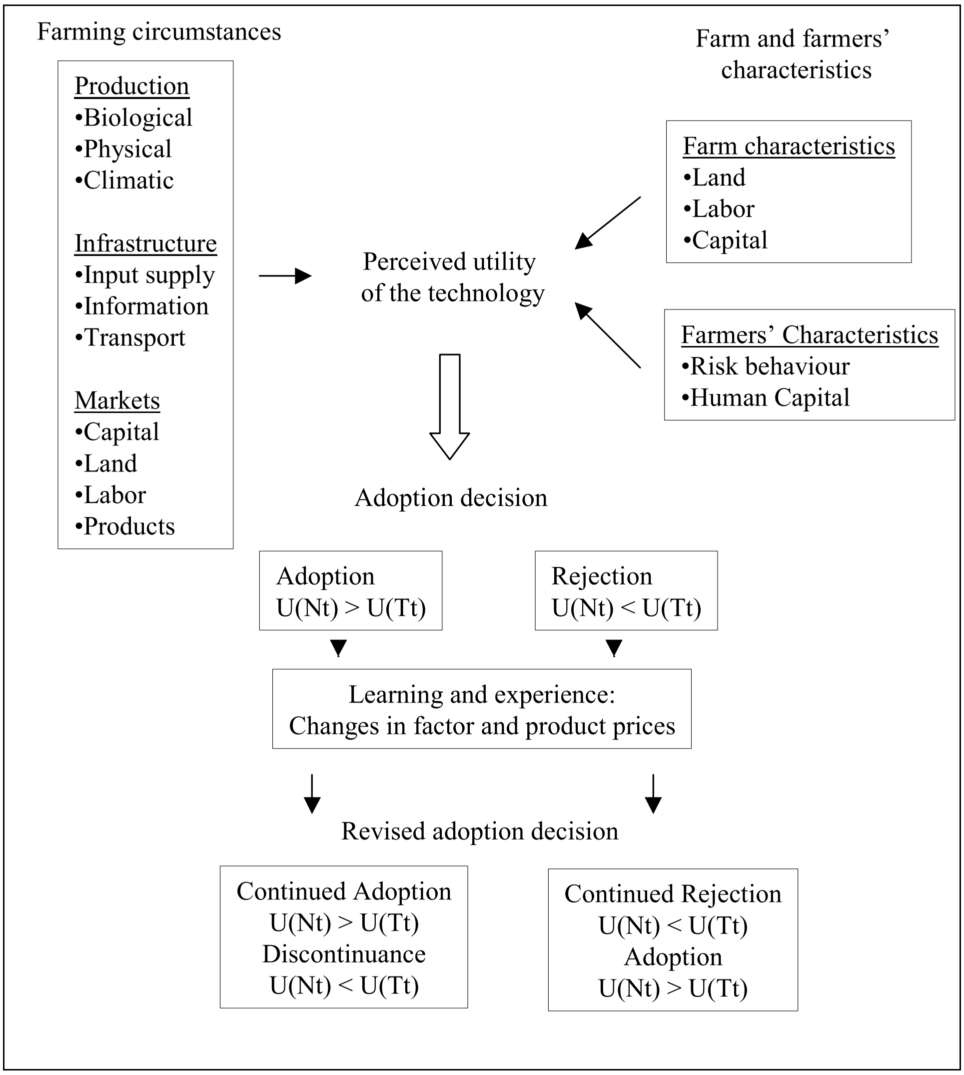
Labor markets result from a dualistic structure. In locations with a high population density, a scarcity of land and small farm sizes, the marginal product of labor on family farms is pushed beyond the point of equality to the market wage. The internal family "wage" is the share of each working member in the total value product of the farm (Gerber, 2004). This is equal to the average product of labor, which is greater than the marginal product, implying that farm households do not hire out labor at a wage below their average product. Family labor is therefore intensively used and at low marginal productivity (ibid.).

(b) Characteristics of the farms. Farm characteristics are the endowment of the individual farm with factors such as land, labor or capital. One of the first factors on which empirical adoption literature has focused is farm size which is most often represented by the number of hectares. Farm size can have different effects on the rate of adoption depending on the characteristics of the technology and the institutional setting. If farm size is discussed in the context of fixed adoption costs, a distinction must be made between "divisible" and "lumpy" technology (Feder et al., 1985). The first category of technology can be adopted by both small and large farms because the relative capital outlay remains equal for both. Fertilizer, for example, can be bought in divisible amounts and therefore can be adopted by farmers regardless of their size. On the other hand, the adoption of "lumpy" technology, such as improved cattle, requires a certain amount of capital. Consequently, this kind of technology will be adopted faster and more widely by large farms (Gerber, 2004).

The availability of labor also affects farmers' decisions to adopt a new technology. Some new technologies can save labor and will be adopted faster by farmers with lack of labor, ceteris paribus. In contrast, farmers will reject a technology that increases the amount of labor required for production. Farmers are assumed to evaluate the labor requirement of a new technology carefully and compare it with their own labor capacity, especially in peak seasons (ibid.). Hence, labor saving technologies have a better chance of being adopted in areas where labor is scarce in relation to land and capital. As explained in relation to the functioning of markets, the need to undertake fixed investments may prevent small-scale farmers from adopting quickly. Non-farm income can help to overcome working capital constraints, or may even finance the purchase of a fixed investment type of innovation. In this case, a "surplus" of family labor could compensate for lack of capital and might therefore be viewed as factor substitution.

(c) Characteristics of the farmers themselves. Perceived distribution of production functions is not only caused by actual and perceived farming circumstances, but also by the farmers' perceptions of the technology's characteristics (Gerber, 2004). Education, which is widely considered to be the most important form of human capital, influences a farmer's perception regarding new technology. It is assumed that farmers with better education have a higher capability to acquire and process information. Furthermore, additional schooling may help farmers experiencing a high degree of uncertainty to make better adoption decisions and increase farm profitability.

Figure 2.1: The resource-constraint approach of technology adoption



Where U = expected utility, Nt = New technology and Tt = Traditional technology.
Source: adapted from Gerber (2004).

Regarding maize technology adoption, from the empirical evidence point of view, Heisey et al. (1998) found in an analysis of hybrid maize adoption patterns in 32 developing countries that hybrid maize is likely to be adopted more extensively where farmers are large, markets are well developed, and maize is grown as commercial crop. They argue that the profitability of adopting hybrid maize is influenced by three non-price factors at the farm level: (1) the yield advantage of hybrids, (2) the seed rate, and (3) the cost of capital and the perceived riskiness of the technology. The most important factor that affects the adoption of maize hybrid is the price of seed. Unlike most of the other factors, the price of seed is to a large extent endogenously determined in the sense that it reflects the interaction of demand and supply forces. Of course, not all economies operate along pure free-market principles. Many governments intervene in seed markets directly or indirectly. Thus, maize hybrid seed produced by public programs is often sold at lower price than by private companies. The empirical experience shows that in most developing countries in which maize hybrid have been widely adopted by small-scale farmers, seed-to-grain price ratios are low, usually less than 10:1. Later, during the maturity phase of the seed industry, when farmers have come to appreciate the benefits of hybrids and are regularly replacing their seed, seed-to-grain price ratios rise sharply, often stabilizing in the rage of 25:1 to 30:1 (Heisey et al., 1998).

Regarding maize technology adoption in Mexico, Aquino's (1998) findings show that adoption of improved maize germplasm has been inconsistent. Commercial maize producers in northwest and central parts of the country often plant hybrids, but small-scale farmers who make up the vast majority of the rural population continue to plant local varieties with low production potential. Most of small-scale farmers are located in the central and southern parts of the country and adoption of improved maize varieties is negligible. Aquino argues that the low rate of maize adoption can be attributed to factors that affect both the supply and demand for improved technology. On the supply side, researchers have not always been able to develop improved germplasm that meets the needs of rural households. Relatively few OPVs and hybrids have been suited to agroclimatic circumstances, management practices and consumption requirements of small-scale farmers. In cases where appropriate materials have been developed, the extension and input delivery systems have failed to transfer them to farmers. Many small-scale producers remain only dimly aware of the potential benefits of improved germplasm and crop management practices, and most rural households lack the resources to purchase improved seed and the skills needed to mange it properly. These problems–which spring from the extreme poverty of Mexico's rural people, their lack of education, and their incomplete integration into the national economy–have contributed to the lack of adoption.

Brush and Chauvet (2004) argued that a large majority of maize producers in Mexico has been exposed to new technology and can be described as partial adopters in two senses. First, new maize technology is rarely adopted as a "package" of inputs–seed of improved varieties, fertilizers, pesticides, irrigation, and mechanization. Second, new maize technology is adopted more extensively in the commercial sector than among non-commercial and semi-commercial farmers.

They point out that partial adoption by type of farm and technology means that a large majority of Mexican maize farmers are aware of new technology, experiment with it, and choose what elements to adopt and which ones to ignore. Their results show that few Mexican agricultural systems have experienced dramatic and rapid changes such as experienced in the U.S. with mechanization and the diffusion of commercial hybrids or in parts of Asia where the Green Revolution occurred between 1966 and 1980. Nevertheless, incremental changes and partial adoption of new technology are commonplace in almost all of Mexico.

2.2 Crop genetic resources conservation

According to Convention on Biological Diversity, agricultural biodiversity provides not only food and income but also raw materials for clothing, shelter, medicine, breeding new varieties, and performs other services such as maintenance of soil fertility and biota, and soil water conservation, all of which are essential for human survival (CBD, 2007). Consequently, there has been considerable public debate about the economic value of biodiversity and whether economists should attempt to value it at all. Some contend that it is inherently unethical to employ a utilitarian discipline like economics to assess the relative costs and benefits of species survival (Smale, 2006); others argue that biodiversity must be priced to ensure that what matters to society is conserved. Economists' emphasis on value has often distanced them from natural scientists, especially if the purpose of valuation is to justify rather than to explain human behavior (Dyer, 2006; Smale, 2006).

The world's array of crop varieties is a consequence of human choices in close interaction with natural selection process, on-farm (*in-situ*) where crop genetic resources are managed by farmers, and off-farm (*ex-situ*) where they are managed by plant breeders or gene banks (Smale, 2006). Relative to other areas of public policy, economics has contributed relatively little to debates about the value of these resources.

Smale (2006) argues, for instance, that it is now generally accepted that Asia's seed-based Green Revolution generated substantial benefits beyond (the adopting) farmers in irrigated production environments but large numbers of food-insecure families remain in the less productive lands of that continent. Farmers like these, who manage and supply crop genetic resources, often face unpredictable and undifferentiated markets for their products, relying on their own harvest for at least some of the goods consumed by their families. The decisions of these small-scale farmers are also a subject matter of this dissertation.

To conserve crop diversity, policy makers have to deal with issues of crop diversity that include property rights, uncertainty, valuation, measurement, and the relationship between poverty and crop diversity. On top of these, institutional and policy failures still remain as challenges for most developing countries. The potential *trade-off* between crop diversity and diffusion of modern varieties as well as market development is another source of concern.

Research by Brush et al. (1992) in Peru, Meng (1997) and Meng et al. (1998) in Turkey and van Dusen (2000) and van Dusen and Taylor (2005) in Mexico developed approach that serves as a starting point for most of this section.

2.2.1 Crop diversity conservation: current paradigms

According to Wale-Zegeye (2004) there are two influential views (*utilitarian* and *ethical*) as to the conservation of biodiversity in general and crop diversity in particular. While proponents of the utilitarian view emphasize the use value of crop diversity, supporters of the ethical view emphasize the existence value of crop diversity. The utilitarian view, accepted by most economists, asserts that crop diversity has to be conserved based on its marginal utility to society. The most immediate reasons for caring about biodiversity in economics are instrumental and utilitarian. On the contrary, the ethical view claims that all biological resources are valuable and should be conserved for moral and ethical reasons. Unlike the utilitarian approach, moral and ethical reasons for conservation do not lend themselves to calculations of exact financial value. In the presence of these differences, however, the ethical and utilitarian reasons for conservation do also overlap.

Both economists and biologists acknowledge that crop diversity is valuable. A question on which economists might differ from biologists is how many species should be conserved. To the economist, costs of conserving necessitate some implicit ranking of genetic resources based on their value. The resource allocation decision in economics is guided by anthropocentric values of resources.

From a utilitarian perspective, conservation cannot be regarded as an objective in itself. Crop diversity conservation should be undertaken to the ultimate goal of serving human kind. That is why the Convention on Biological Diversity [CBD], among other things, is concerned with not only conservation but also the sustainable use of biodiversity for development (Wale-Zegeye, 2004).

Of course, it is not possible to preserve everything. For economists, it is neither meaningful nor practical to deal with conservation of everything. Given all the uncertainties involved about the costs of losing and benefits of conserving biological diversity, a concept like “the most valuable species” is generally problematic (Wale-Zegeye, 2004). This is because of the fact that the traditional economic value of a species is of no significance in determining its usefulness as an environmental indicator.

The approach that says every life form must be preserved tends to deny the possibility of setting priorities (Wale-Zegeye, 2004). As it will be made clear subsequently, the thesis generally follows the utilitarian approach and indicates the need for priority setting, identifying crop varieties conserved *de-facto* and those that require on-farm conservation schemes.

2.2.2 Maize conservation *de-facto*

Non-adopters are farmers who planted traditional varieties. Brush (1995) and Brush and Meng (1998) have argued that the persistent cultivation of landraces in centers of crop diversity termed as *de-facto* biodiversity conservation. As well van Dusen (2000) who argued that *in-situ* conservation of traditional varieties could be modeled as the inverse of adoption of modern varieties, in this sense, non-adopters play a key role in diversity conservation.

However, here the main question is why the traditional varieties are important. Smale, Bellon and Aguirre (2001) argued that the landraces have private and social values, private for the farmers who grow them, and social value because plant breeders use landraces as sources of novel alleles (gene type) or gene combinations to improve the crops that produce the food, fodder and fiber on which societies depend. Besides, Bellon and Taylor (1993), van Dusen (2000), and Pandey (1998) argued that germplasm of crop landraces provides the material from which high-yielding seed varieties have been developed by international and national agricultural research centers.

In this sense the fears of maize genetic erosion are due to the introduction of modern varieties [MV]. Smale et al. (2001) argue that over the course of this century, the products of modern plant-breeding programs have replaced the landraces of major cereals in many regions of the world. Also Brush, Taylor and Bellon (1992) have showed the empirical evidence of crop diversity erosion due to adoption of MV in the Andean potato area.

Furthermore Perales, Brush and Qualset (2003a) pointed out that as in other centers of crop genetic resources, there is concern in Mexico about the genetic resources of native crops are imperiled by increased population, technology diffusion, market development, international commodity trade, and off-farm employment.

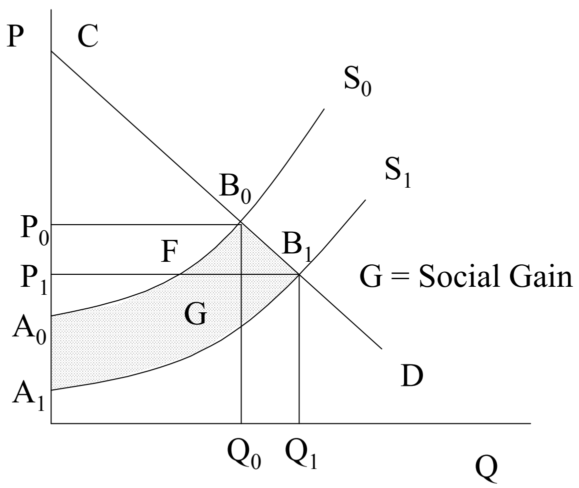
Lastly, Dyer and Yunez-Naude (2003) argue that in 1994, NAFTA opened the door to the free flow of maize seed across North America. Since then, the door has been set ajar in an effort to prevent the release of transgenic maize into the Mexican landscape. The eventual arrival of transgenic maize in Mexico–maize's center of diversity–has concerned scientists for years; but it was until Quist and Chapela (2001) reported the presence of transgenic constructs in Oaxacan landraces that it became a national concern. The scientific community, both in Mexico and abroad, still debates a variety of questions on the possible spread of transgenes, including the veracity of the claim and its possible consequences: the appearance of weeds, resistant pests or resistance to antibiotics, and the genomic instability in maize. From an in-situ conservation perspective, the spread of transgenes to maize landraces represents an entirely new type of threat. Previous threats to in-situ conservation were confined to one of two types: landrace displacement or crop replacement.

2.3 Agricultural technology and poverty

There is a general consensus among researches that Green Revolution played a key role in the research and development [R&D] in less developed countries [LDC], because the economic base of most of LDCs is generally dominated by agriculture and the livelihood of the majority of their inhabitants depends on agricultural output. Consequently, a key issue in the economics of technology adoption is to understand the impact of technology change on prices and, in particular, the wellbeing of the farm population. Agriculture in developing and developed countries has been subject to government interventions that, in turn, affect technological change, as well as efforts for private sectors. From the theoretical point of view Sunding and Zilberman (2001) show the returns to public and private research and development in agriculture rely on partial equilibrium analysis, depicted in Figure 2.2.

The model that Sunding and Zilberman propose considers an agricultural industry facing a negatively sloped demand curve D. The initial supply is denoted by S_0, and the initial price and quantity by P_0 and Q_0, respectively. Research, development, and extension activities led to adoption of an innovation that shifts supply to S_1, resulting in price reduction to P_1, and consumption gain Q_1. The social gain from the innovation is equal to the area $A_0B_0B_1A_1$ in Figure 2.2 denoted by G. If the investment leading to the use of the innovation is denoted by I, the net social gain is $NG = G–I$, and the social rate of return to appropriate research development and extension activities is NG/I.

Figure 2.2: Social benefits from technology adoption



Source: Adopted from Sounding and Zilberman (2001)

The social gain from the innovation is divided between consumers and producers. In Figure 2.2 consumer gain is equal to the area $P_0B_0B_1P_1$. Producer gain is $A_0FB_1A_1$ because of the lower cost and higher sales, but they lose $P_0B_0FP_1$ because of lower price. If demand is sufficiently inelastic, producers may actually lose form public research activities and the innovations that they spawn. Obviously, producers may not support research expenditures on innovations that may worsen their wellbeing, and distributional considerations affect public decisions that lead to technological evolution.

From the empirical point of view, the relationship between agricultural technology and poverty reduction has been a source of intense debate in the past decades. The literature on the Green Revolution technologies argues that “the higher yielding plant varieties, the greater the use of fertilizers and the increased irrigation” and have been essential for the decline in poverty in rural areas. The expanded food output from the new technology has contributed to lower food prices globally. Average caloric intake has risen as a result of lower food prices, with corresponding gains in health and life expectancy (Mendola, 2007).

Looking back in history, evaluations of extension-led agricultural development programs (including many integrated rural development programs) in the late 1950s indicated relatively slow progress in productivity gains. The economist Schultz (1964), in his classical work, “Transforming Traditional Agriculture”, argued that farmers with traditional technology (including farmer-selected crop varieties and livestock breeds) were actually efficient[9]. Schultz argues that development programs would have to deliver new technology to poor farmers in developing countries in order to improve their situation. In Schultz's view, the location-specificity of crop and livestock technology meant that farmers in many parts of the world simply lacked access to modern technology; without the development of locally adapted technologies, they simply did not have a viable alternative to traditional practices (Schultz, 1964). These conditions led to the development of a system of international agricultural research centers [IARC] that were eventually organized under the rubric of the Consultative Group for International Agricultural Research [CGIAR]. By the late 1960s, the international centers appeared to be making significant progress. Improvements in crop productivity were most apparent in two major cereals grains produced in developing countries, wheat and rice. In both crops, improvement was based on a new "plant-type". Specifically, this plant type was shorter and earlier maturing, with less photoperiod sensitivity, than traditional tropical and subtropical varieties (Evenson and Gollin, 2003). These new plant types were popularized and represented as the foundation for a Green Revolution in developing countries.

A large body of literature now exists that discusses the Green Revolution. The literature includes studies claiming a miraculous transition to high productivity growth rates; it also includes studies that criticize the Green Revolution for many perceived failures. Early contributions suggest strongly that the primary nutritional gains for the poor came through the effect of agricultural research on improving their purchasing power, both by raising their incomes and by lowering the prices of staple food products.

From the global impact of R&D point of view, in 1998, the CGIAR's independent Standing Panel on Impact Assessment [SPIA], which was called the Impact Assessment and Evaluation Group [IAEG] initiated a major study of the impact of CGIAR's germplasm improvement activities since the beginning of the Green Revolution compiled in Evenson and Gollin (2003). It builds on the impact assessment work undertaken by the CGIAR centers and their partners to monitor and document the released varieties and the corresponding adoption rates and production gains for

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[9] In Schultz's terms, they were "poor but efficient", or equivalent, "efficient but poor".

individual crop commodities. Evenson and Gollin's (2003) work provides the most comprehensive documentation of crop genetic improvement impacts. The study covers both the production and diffusion of improved crop varieties for 11 important CGIAR mandate food and feed crops (rice, wheat, maize, sorghum, millet, barley, beans, lentils, groundnut, cassava, and potato) in developing countries over the period from 1960 through to the 1990s.

The methodology for this assessment required a multi-market, multi-country model where crop supply and crop demand factors determine market-clearing prices, quantities produced and consumed, and international trade volumes. For this purpose, Eveson and Rosegrant (2003) with the help of the International Model for Policy Analysis of Agricultural Commodities and Trade [IMPACT] tool, developed by the International Food Policy Research Institute [IFPRI], made a group of "counterfactual" simulations. The counterfactual simulations asked the following questions:

(1) How would food prices, food production, food consumption and international food trade have differed in the year 2000 if the developing countries of the world were constrained to have had no Crop Genetic Improvement [CGI] after 1965, while developed countries realized the CGI that they historically achieved?
(2) How would food prices, food production, food consumption and international food trade have differed in the year 2000 if the IARC system had not been built (and thus the IARC and CGI contributions had not been realized), but NARS CGI gains in both developed and developing countries realized?

The basic conclusions of the study on poverty can be summarized as follow (it is important to emphasize that there are marked differences in results between crops and between regions and countries):

i. World food and feed grain prices (weighted by production) would have been 18-21% higher than they actually were, (and 35-66% higher in the absence of any CGI activity[10];

ii. World food production would have been 4-5% lower–and not lower than that because of 1-2% higher production in the developed countries in response to higher prices, while developing countries would have produced 7-8% less;

iii. Area planted to cropland would have been significantly higher, particularly for crops like rice. For all food crops, total acreage would have expanded by 1.5-2.7% (5-6 million ha in developed countries and 11-13 million ha in developing countries);

iv. Food consumption per capita would have declined significantly for many groups. For all developing countries, the average reduction in caloric availability per capita would have been 4.5-5% and up to 7% in the poorest regions. Furthermore, approximately 2-2.3% more children (13-15 million)–predominantly located in South Asia–would have been malnourished than otherwise, and infant mortality would have been higher;

v. Imports of food in developing countries would have been about 5% higher (Evenson and Gollin, 2003).

As Evenson and Gollin conclude that consumers especially poor consumers benefit most from all from agricultural research. Farmers are consumers too and for the world's smallest farm producers the total consumer gains are large. From the producers' side, benefits also accrue. By adopting improved varieties, many farmers lowered costs of production and generated higher rates of return from their land, labor and capital. This, in turn, had positive impacts on income and helped reduce poverty in both land owning and labor producing households in some agricultural regions, but by no means all. An indirect spillover effect from modern variety adoption in other areas was declining crop

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[10] With respect to impacts on poverty alleviation, Evenson and Golling (2003) conclude that the poor would have been hurt more by the higher prices in the absence of the CGIAR because they spend a higher of their income food.

prices. In the areas not touched by the Green Revolution, costs of production did not fall, and this, in turn, had an adverse effect on farmers' income in these regions.

The impacts from the country level point of view are found in de Janvry and Sadoulte (2002) who note that technological change has both direct and indirect impacts on poverty, and the same might be said about technological impact in other areas. Direct impacts include increased productivity of land and labor, greater food security, lower cost of production, and increased income. Indirect impacts include lower prices for food and employment and wage effects in agriculture. In a simulation of the impacts of different scenarios of technological change estimates that with new technologies small and medium-scale farmers in Latin America capture greater benefits and suffer less decline from falling commodity prices than large farmers (de Janvry and Sadoulet, 2002).

Another assessments of the relationship between agricultural productivity, growth, rural development and poverty reductions have stressed the role of technology spillovers through land and labor markets, on the one hand, and through the linkages from farming to the rest of the economy on the other. Pinstrup-Andersen and Hazell (1985) argued that the landless labor did not adequately share in the benefits of the Green Revolution because of depressed wage rates attributable to immigrants from the other regions. David and Otsuka (1994), on the contrary found that immigrants shared in the benefits of the Green Revolution through increased employment opportunities and wage income. Furthermore, the recent availability of panel data, especially in India, has motivated many innovative micro-econometric analyses that validate the pro-poor bias of agricultural growth. Datt and Ravallion (1996) provide some evidence that agricultural growth is more important than non-agricultural one for poverty alleviation in India regions with poor initial conditions. In Datt and Ravallion (1998) they further explain the pro-poor character of agricultural growth by showing that land yield is inversely related to a variety of poverty measures, with an elasticity ranging from one to two. Foster and Rosenzweig (2004), on the other hand, provide evidence that income growth from non-farm sector over the last 30 years in rural India has been substantial and, therefore, it ought to be complemented in policy recommendations to investment in agricultural technology. Additional, computable general equilibrium models have been used extensively to estimate the effect of agricultural technology adoption and agricultural growth on poverty (de Janvy and Sadoulet, 2000).

Derived from the previous literature, there are several plausible arguments to expect that agricultural technology contribute to poverty alleviation. On the basis of the literature, the analysis is looking to distinguish between *direct* and *indirect effects* of technology adoption on households' well-being. Direct effects are gains for the adopters –in terms of higher yields, increased factor productivity and food security, whilst indirect effects are gains derived from the adoption of others. The latter effects may be transmitted through the market, leading to less food prices, variations in prices of inputs, job generation, non-farm sector growth and national level growth linkages effects.

Indirect effects, which have to do with the impact of technological change on the poor as laborers and consumers, have often been emphasized as the main channel through which agricultural technology may be pro-poor. The major argument is that indirect effects –through lower food prices, employment generation and economies of scale- can benefit a broad spectrum of poor farmers at national level, including landless farmers, net food-buying smallholders, net labor-selling small scale farmers, non-agricultural rural poor households, and even urban poor households.

The impact from the household level (microeconomic) point of view Adato et al. (2007) in their latest work, argue that to fully assess the impact of agricultural research, it is important to establish a counterfactual (what happened in the absence of the technologies). Kerr and Kolavalli (1999) found that the lack of an adequate counterfactual was a key weakness of many studies on the impact of agricultural research. Household studies provide rich insights into how technology can impact on welfare outcomes at the intra-household and inter-household levels within adopting regions. But they are insufficient to capturing the indirect impacts of new technologies that can arise through labor markets, the non-farm economy, and food prices. These factors not only affect the rural poor in adopting regions, but can affect poor people everywhere, including urban poor (Adato et al., 2007).

Hossain et al. (2007) found that the linking of the quantitative and the qualitative methodologies proved instructive in broadening the ability of the project researches to examine the relationship between technology adoption and poverty, particularly in picking up dynamic process. Whereas the quantitative survey data speak of changes in household structure, land ownership, and change in occupation and income, the qualitative data provide insight on the nonincome dimensions of poverty and social and institutional processes that impact on poverty and vulnerability, the particular implications for the poor are the prioritization of assets; the importance of the health; trust and social networks; and the complexity of gender issues (Hossain et al., 2007).

In particular some studies carried out in Mexico by social scientists are divided in their conclusions about bias in agricultural technology in Mexico. One group, represented by Hewitt de Alcantara (1976), concludes that agricultural research and technology in the country have an urban-industrial bias that is unfavorable to the poor and to small-scale farmers. While agricultural technology is theoretically scale-neutral, the conditions of different producers allow the wealthiest farms to benefit most from new technology. In other words, by not being specifically pro-poor, agricultural technology is *de facto* pro-rich. To this group, the result of technological change has been increasing impoverishments of peasant producers and increasing control by wealthy, industrial producers.

Another group of social scientist differs in their conclusion about the impact of technological change in Mexican agriculture. This group includes Bellon and Risopoulos (2001), Bellon et al. (2003) and de Janvry and Sadoulet (2002). While this group recognizes the persistency of poverty, it finds that agricultural technology, such as chemical fertilizers and improved maize varieties, benefits peasant producers. An implication is that the cause of continued or worsening poverty cannot be attributed to technological change and that new technology may alleviate poverty.

Bellon et al. (2003) and Bellon et al. (2007) researched the use of improved, open-pollinated maize varieties in Oaxaca and Chiapas. Extremely poor, poor, and non-poor farmers cannot be distinctly separated in their use of maize varieties that are descended from hybrid or improved, open pollinated varieties. The rate of using these varieties does not conform to the trajectory from extremely poor to non-poor and farmers in all three categories recognize the traits of improved maize as being beneficial to them.

Chapter 3
Theoretical framework

This chapter presents the theoretical framework to analyze household farm motivations to adopt modern maize varieties as well as to conserve crop genetic resources (basically maize landraces, beans and squash). The section also provides the framework for the analysis of the impact of improved germplasm adoption on poverty alleviation. This theoretical framework is the basis for the econometric analyses introduced in Chapter 5. A basic theoretical model is presented and extended in order to take into account the particular case of maize adoption and maize genetic biodiversity conservation following van Dusen (2000), Wale-Zegeye (2004), and Abdulai and Binder (2006) and Abdulai and Delgado (1999).

3.1 Basic households model

Economic theory suggests that different factors affect farmers' crop and variety choice (e.g., modern or local maize varieties). Reviewing the available literature reveals that the possible factors are heterogeneity of farmers' resources (mainly land), resource endowment (education, labor, and wealth) multiplicity of farmers' household needs (food, fodder, trade), access to markets, and income diversification motives.

The effect of household resource endowment (like labor) on farmers' incentives to adopt an improved seed or conserve traditional varieties depends on the labor intensity of growing each type of crop. Farmers' experience suggests that growing modern varieties (improved germplasm) is labor intensive. Modern varieties are labor demanding because they are generally adopted as technology package (seed, fertilizer, pesticide or fungicide, and some times machinery). With regard to traditional varieties, experience suggests that are less labor and resource demanding (Bellon and Risopoulos, 2001).

The theoretical model outlined below is meant to incorporate each of these variables step by step. Economic models for analyzing modern crop variety adoption and diversity conservation are derived from the partial adoption literature (Feder et al., 1985; Feder and Umali, 1993) and agricultural household models (Singh et al., 1986). The analytical framework presented here derives from on-farm crop choice as the result of farmers' utility maximization constrained by resources endowment. The model formulation follows van Dusen (2006). The main difference is that this model is risk neutral. The local maize varieties or landraces produce low yields, and in particular, do not require modern inputs (fertilizer, pesticides or herbicides). Additionally, the small-scale farmers usually see and ask their neighbors about the new technology's performance, i.e., they are skeptical to introduce new varieties in their seed-pool. Given that the farmer is familiar with the landraces and maize yield performances, it is assumed for simplicity that this technology is risk free.

The household farm is the basic unit of management where decisions and actions are taken that affect crop diversity. The model depicts a farm family that consumes both household's production and goods purchased in the market. The farm family also produces agricultural commodities either for consumption or sale to the markets, combining its labor, land and other capital endowment with purchased inputs, subject to resources and markets constraints (Singh et al., 1986; de Janvry et al., 1991).

In the basic model the household obtains utility from consuming crops $i = 1, 2, \dots$ I, any or all of which it may also produce. Let Ω_i denotes consumption of good i and let consumption of all other market goods be denoted by M. Household utility is affected by exogenous socio-economic, cultural or other characteristics denoted by a vector Ψ_{HH}. Households maximize utility subject to a full income constraint, with income composed of farm income, exogenous income E and an endowment of family time T valued at the market wage, w.[11] Households choose which of j crops, $j = 1 \cdots J$ to produce and the output of each crop, Q_j. Farm income is the value of production (at market price) net of market input costs. Household production is carried out subject to

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[11] In a model focusing on migration the household could choose time allocation to different off-farm activities.

technological constraints embedded in a cost function, $C(Q;\Psi_{Farm})$, where Ψ_{Farm} is a vector of exogenous farm characteristics. Market constraints on production and/or consumption are functions of exogenous characteristics Ψ_{Market}.

This model can be represented mathematically as:

$$\max_{\Omega,Q} U(\widetilde{\Omega},M;\Psi_{HH}) \tag{3.1}$$

$$M = p(\widetilde{Q}-\widetilde{\Omega}) - C(Q;\Psi_{Farm}) + E - wT \tag{3.2}$$

$$H_i(\widetilde{Q},\widetilde{\Omega};\Psi_{Market}) = 0 \tag{3.3}$$

Market constraints, represented by the functions $H(\cdot)$, could take many forms. Under certain market conditions reflected in Ψ_{Market}, such as high transactions costs (de Janvry et al., 1991) consumption demands must be met from own production; i.e., if the constraint is binding, $Q_i - \Omega_i = 0$. In this case the market constraint would take the form, $i = 1 \cdots I$,

$$H_i(Q_i,\Omega_i;\Psi_{Market}) = Q_i - \Omega_i \tag{3.3'}$$

if the market is missing,

$$H_i(Q_i,\Omega_i;\Psi_{Market}) = 0 \tag{3.3''}$$

These constraints represent costs of transacting in markets for consumption goods. When the household can supply itself with good *i* in the market with no transaction costs, constraint $H(\cdot)$ drops out. When transactions costs, characterized by Ψ_{Market}, force the household to satisfy consumption from own production the function $H(\cdot)$ binds (van Dusen, 2006). Market characteristics Ψ_{Market} determine whether a household faces transactions costs for each crop *i* the household consumes. In the case of migration this means that a required input (family labor) is required (in fixed quantities in a Leontief sense) for the production of certain products (Q_i). When the market restricts the availability of this input, it restricts corresponding outputs and thus the choice of crop activities.

The household chooses a vector of consumption levels, $\tilde{\Omega}$, and outputs levels, $\tilde{Q}$. Letting λ denote the shadow value of income and γ, $a(1 \times I)$ vector of shadow values γ_i on the market constraints for goods $i = 1, \cdots I$, the Lagrangian corresponding to this general model is:

$$\begin{aligned} L &= U(\tilde{\Omega}, \tilde{M}; \Psi_{HH}) \\ &+ \gamma(\tilde{Q} - \tilde{\Omega}) \end{aligned} \qquad (3.4)$$

where $\gamma_i(Q_i - \Omega_i) \qquad \forall_i$

The first-order conditions are:

For all consumed goods $\Omega_i \quad U_{\Omega_i} + U_M(p_i) - \gamma_i = 0$ (3.5)

For all produced goods $Q_j \quad U_M(-C_{Q_j}, \psi_{Farm}) + \gamma_i = 0$ (3.6)

For all tradable goods $p_i = \overline{p_i}$ and $\gamma_i = 0$ (3.7)

(where $\overline{p_i}$ is an exogenous market price)

For non-tradable goods $p_i = \rho_i$ and $\Omega_i - Q_i = 0$ (3.8)

where ρ_i, the unobserved shadow price for good *i*, is determined by the internal equilibrium of supply and demand for good *i*:

$U_{\Omega_i} + U_M(\rho_i) = -U_M(-C_{Q_j})$, $U_{\Omega_i} = U_M(C_{Q_j} - \rho_i)$,

$$\frac{U_{\Omega_i}}{U_M} = C_{Q_j} - \rho_i \qquad (3.9)$$

Constraint (3.3) represents transactions costs in obtaining consumption good Ω_i. When the household can transact for good *i* in the market without transaction costs, constraint $H(\cdot)$ drops out (i.e. the shadow value on the constraint, γ_i, is 0; note that this model collapses to the standard agricultural household model presented in Singh et al. (1986) when this constraint is not binding for all *i*. However, when transactions costs force the household to satisfy consumption from own production, the constraint is binding. The market characteristics, Ψ_{Market}, determine whether a household faces transactions cost for each crop *i*.

The general solution to the household maximization problem when the constraints bind yields a set of constrained optimum-production levels, $\tilde{Q}$, and consumption levels, $\tilde{\Omega}$:

$$\tilde{Q} = \tilde{Q}_j(p, \Psi_{HH}, \Psi_{Farm}, \Psi_{Market}, M) \tag{3.10}$$

$$\tilde{\Omega} = \tilde{\Omega}_j(p, \gamma^c, \Psi_{HH}, \Psi_{Farm}, \Psi_{Market}, M) \tag{3.11}$$

where γ^c denotes full income associated with the constrained optimal production level Q^c. For some crops the optimal production level may be 0; therefore, the outcome on Q^c will determine which of the j crops the household chooses to produce.

3.2 Technology adoption

Given that one of the focuses of the study is to examine the factors that influence the maize technology adoption, the analysis assumes that small-scale farmers choose between improved germplasm and other local varieties. To address the economics of maize adoption, an adoption model of agricultural innovations is formulated in this section (Feder et al. 1985; Feder and Umali, 1993) within the farm household framework of Singh, Squire and Strauss (1986) and following the basic model in section 3.1 above.

Farmer's land allocation decisions about whether to grow a modern variety (hybrid or OPV) can be understood for Mexican small-scale farmers in the context of household decision-making rather than profit maximization. In this theoretical framework, the agricultural household maximizes utility over a set of consumption items (Ω_{farm}) generated on the farm, and a set of purchases of market goods (M_{NFarm}). The utility a household derives from various consumption combinations and levels depends on the preferences of its members. Preferences are in turn shaped by the characteristics of the household Ψ_{HH}, such as the age, education of its members, and wealth.

$$\max_{\Omega_{farm}, M_{NFarm}} U(\Omega_{Farm}, M_{NFarm}; \Psi_{HH}) \tag{3.12}$$

Amounts of farm produce consumed on farm (Ω_{farm}) or sold are from a vector Q of farm outputs. Decisions are constrained by a fixed production technology that combines purchased inputs (X), labor (L), and an allocation of a fixed land area $(A = A^0)$ among crops and maize varieties, given the physical conditions of the farm Ψ_{Farm}. Each set of area shares (α_{ij}) among crops and maize varieties sums to unity when the seasonal land constraint binds. The choice of area shares implies a level of farm outputs, and vice-versa. The farm output function can then be expressed as:

$$Q = C(\alpha, X, L; A, \Psi_{Farm}) \tag{3.13}$$

The objective function is then expressed as:

$$\max_{1>\alpha_{11},\alpha_{ij},\ldots\alpha_{mm}\geq 0;\Omega_{Farm},M_{NFarm},X,L} V(\Omega_{Farm}, M_{NFarm}; \Psi_{HH}) \tag{3.14}$$

Subject to: production function: (Q) equation (3.13); labor constraint (T) equation (3.15), and income constraint: equation (3.16).

Where the choice variable are area shares (α_{ij}), other production inputs, and consumption levels. Interior solution may not be found for each crop or maize variety, and some area shares may be censored at zero.

Choices about the allocation of household labor and hired labor are constrained by total time (*T*) available for farm production (*F*) and leisure (*l*),

$$T = F + l \tag{3.15}$$

Full income in a single decision-making period is composed of the net farm earnings (profits) from crop production, of which some may be consumed on farm and the surplus sold, and income that is "exogenous" to the season's crop and maize variety choices, such as stocks carried over, remittances, pensions, and other transfers from the previous season (Y^0):

$$p_f(Q_f - \Omega_{farm}) - p_x X - wL + Y^0 = p_{NFarm} M_{NFarm} + wF \tag{3.16}$$

A special case of the model is profit maximization. When all relevant markets function perfectly, farm production decisions are made separately from consumption decisions (Singh et al., 1986). The household maximizes net farm earnings subject to the technology and expenditure constraints and then allocates these with other income among consumption goods. The production and consumption decisions of the household cannot be separated when labor markets, markets for other inputs, or product markets are imperfect[12]. Then the prices are endogenous to the farm household and affected by the costs of transacting in the markets. For a good that is not traded, no surplus is sold $(Q-\Omega_{farm}=0)$ and the shadow price that governs the choices of the household is determined by the internal equation of supply and demand for the good, expressing the household's valuation of the good. Market constraints on production and/or consumption can be expressed as functions of exogenous market characteristics Ψ_{Market}. The specific characteristics of farm households (represented by vector Ψ_{HH}) and markets (represented by vector Ψ_{Market}) influence the magnitude of transactions costs involved in market exchanges and through the shadow price, the household's choices.

When consumption and production decisions are not separable, the optimization of equation (3.14) with respect to equations (3.13), (3,15) and (3,16) lead to a reduced Form equation (3.17) expressed in optimal area allocation among crops and maize varieties as functions of a vector of prices (including wage), farm size, exogenous income (remittances or government subsidies), and vectors of farm household, farm physical characteristics, and market features (Feder et al. 1985; Feder and Umali, 1993):

$$\alpha^{*}=\alpha^{*}(p,A^{0},Y^{0},\Psi_{HH},\Psi_{Farm},\Psi_{Market}) \qquad (3.17)$$

3.3 Diversity and conservation in the model

The crop biodiversity within a given household farm is the result of the choice of which crops and varieties to produce, subject to constraints (van Dusen, 2006). This diversity outcome in the constrained case takes the form of a derived demand for number of varieties; van Dusen (2000) has called it *latent diversity*:

$$D^{c}=D(Q_{j}^{c}(p,\Psi_{HH},\Psi_{prod},\Psi_{Market})) \qquad (3.18)$$

Resulting from the farmers' utility maximization subject to income, production and market constraints. In the special case of perfect markets the diversity outcome simplifies to the unconstrained:

$$D^{*}=D(Q_{j}^{*}(p,\Psi_{prod})) \qquad (3.19)$$

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[12] According to de Janvry et al. (1991: p. 1401) a market fails when the costs of a transaction through market exchange creates disutility greater than the utility gain that it produces, with the result that the market is not used for the transaction.

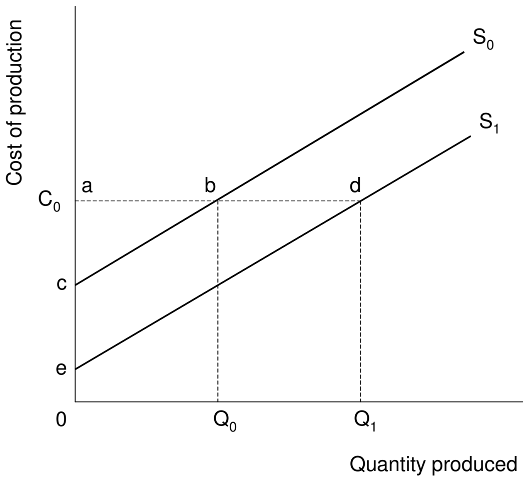
The perfect market case is nested within the general agricultural household model of both production and diversity. Note that $D^c < I$ $(D^* < I)$ when $Q_j^c = 0$ $(Q_j^* = 0)$ for one or more crops.

3.4 Technology adoption and poverty framework

The relationship between technology change and poverty alleviation through effects on agricultural producers is very complex. Farmers are a diverse population and typically adoption of a new technology is gradual and partial. It may also be concentrated regionally. As a result, technical change can have variable effects on farmers' incomes (expenditures) both within and across regions (Kerr and Kolavalli, 1999). Distributional implications for farms of different sizes depend heavily on policies and institutions that condition the incentives and constraints, and in turn govern the decision of whether or not to adopt.

With new, more productive cultivars (improved germplasm) farmers can produce more output at the same cost, or the same level of output at a lower cost. This is presented in Figure 3.1 by a shift in the supply curve from S_0 to S_1. Along S_0, farmers who wish to produce more only can do so at a higher cost, say by adding additional inputs. But with the introduction of new technology the supply curve shifts to S_1. At a given marginal cost of C_0, farmers can raise the quantity they produce from Q_0 to Q_1.

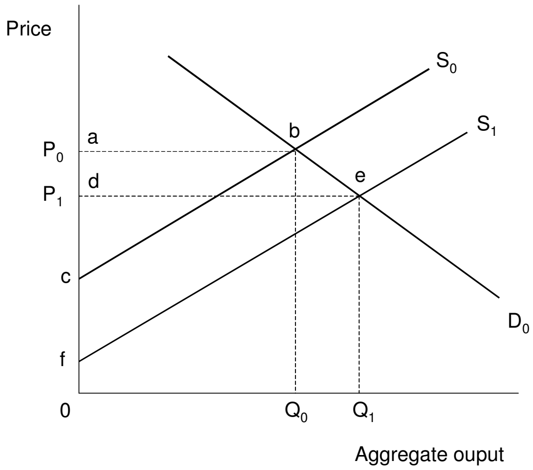
Figure 3.1: Higher output without raising cost



Source: Kerr and Kolavalli (1999)

If all farmers raise their production, the higher aggregate output may reduce the price, from P_0 to P_1 as Figure 3.2. However, this depends on the nature of the economy. If the economy is closed to trade and the country is about self-sufficient in food, then higher supply will reduce output prices as in Figure 3.2.

Figure 3.2: Higher aggregate output without demand shift

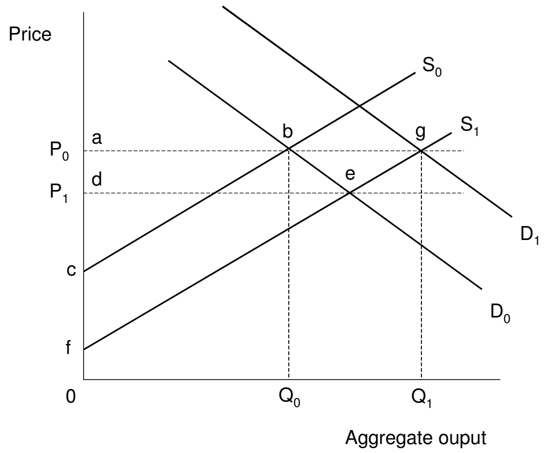


Source: Kerr and Kolavalli (1999)

Farm profit will not suffer as long as marginal production costs fall by more than output prices. In Figure 3.2, initial producer surplus is represented by triangle *abc*, and producer surplus after technical change and a lower price be the rectangle *def*. In this hypothetical case producer surplus is higher after technical change, but this is not necessarily the case.

In a closed economy in which food demand is rising due to higher incomes or population growth, demand will shift from D_0 to D_1 in Figure 3.3; in this case output price will not fall by as much or it may even rise if demand shifts faster than supply.

Figure 3.3: Shift in demand raises price

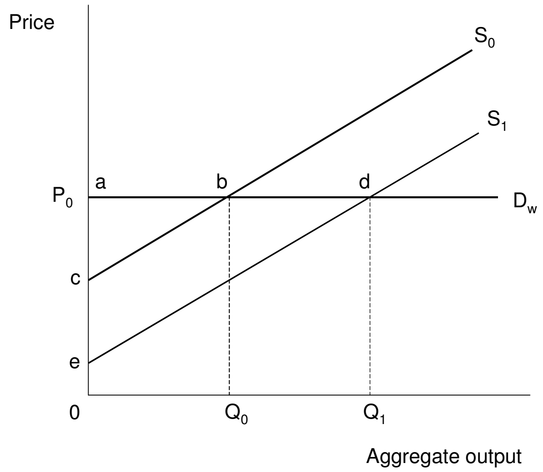


Source: Kerr and Kolavalli (1999)

In Figure 3.3, the shift in demand is sufficient to return to the original price at P_0. Producer surplus enjoyed by farmers is represented by the triangle *agf*, unequivocally higher than the initial level of *abc* regardless of the shape of the supply and demand curves.

In an economy open to trade and small enough not to affect international prices, world demand will absorb the additional output with no downward pressure on output price. In this case the demand curve is represented in Figure 3.4 by D_w, at the constant price P_0, Farmers will benefit unequivocally from lower marginal production costs–they would be able to supply more at a constant price, given the higher revenue and higher net returns. In Figure 3.4 this is represented by an unequivocal increase in producer surplus from *abc* to *ade*. In a large, open economy whose international trade is large enough to affect world prices, the relationships are similar to those in the closed economy case of Figure 3.2 and Figure 3.3.

Figure 3.4: Higher output has no effect on price



Source: Kerr and Kolavalli (1999)

Reviewing, if a small number of farmers adopt the new technology, their supply will shift out from S_0 to S_1 in Figure 3.1, but their increased production will not have much effect on aggregate production. In Figure 3.2, aggregate output would remain at around Q_0 and price at P_0. The adopting farmers would all earn more, because they could produce more at the same cost and receive the same price. On the other hand, if a large number of farmers adopt the new technology while a smaller number of farmers do not, then the non-adopting farmers may actually become worse off. This is because with higher aggregate Q_1, price would fall to P_1 in Figure 3.2 (assuming no change in demand). Adopting farms could remain profitable by producing at a new, lower marginal cost, but non-adopting farmers would face declining net revenues because they would still incur the original, higher marginal cost while receiving a lower price for their output.

Clearly the non-adopting farmers would become worse off in this case; if their returns become negative they would be driven out of business. Even if their returns remain positive, adopting farmers might purchase their land since it would give higher returns to them compared to non-adopting farmers. Even though non-adopting farmers would earn revenue by selling the land, they would lose an important asset and means of livelihood (Kerr and Kolavalli, 1999).

Chapter 4

Description of regions and survey sample

The chapter has two major components: the first one corresponds to the description of village selection process and data collection; the second one presents a statistical description of the basic household characteristics, particularly land endowment and area planted with maize, as well as the maize seed prices and the results of maize collection.

4.1 Village selection and data compilation

The village selection was based on a conceptual matrix that combined: (a) different levels of marginality and (b) levels of diffusion of modern maize varieties through *Kilo por Kilo* government program[13]. Contrasting conditions on both axes are presented in Figure 4.1. Since the focus of this research is on maize technology adoption, the first step was to delimit the areas where the improved germplasm are distributed. Delimiting this area for Oaxaca and Chiapas was accomplished through the use of climatic and elevation model using data from collections of maize landraces accessions at the CIMMYT Gene-Bank. Based on this information the Coast of Oaxaca and Frailesca of Chiapas areas were selected. Second, to identify different levels of poverty within the areas of modern maize diffusion, marginality index developed by the National Council of Population (*Consejo Nacional de Población* [CONAPO]) and Education, Health and Food program (*Programa de Educación, Salud y Alimentación* [PROGRESA]) were used (CONAPO-PROGRESA, 2000).

Figure 4.1: Matrix for village selection

Marginality / Diffusion	Very High	High	Medium
High	2	2	2
Low	2	2	2

The matrix depicts village selection for Coast of Oaxaca and Frailesca of Chiapas. Source: Bellon et al. (2003).

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[13] The database was a component of one CIMMYT's project, more in Bellon, et al (2003).

Operationally the villages were chosen on the medium, high and very high categories of the marginality index. In terms of diffusion, localities were classified as localities with low or high diffusion depending on whether they have been involved in the *Kilo por Kilo* program, although this program is relatively recent (five years), but modern varieties have been available for more than 40 years and distributed by other government programs. The size of the localities ranges between 1,000 and 2,500 inhabitants. The upper bound of 2,500 inhabitants limit correspond to the parameter used in Mexico to define rural population (Urquidi, 2000).

The 12 villages selected include six in the Coast of Oaxaca and six in Frailesca of Chiapas. These villages correspond to two villages per region as per cell in the conceptual matrix –one per region in Figure 4.1. Details on site selection are found in Bellon et al. (2003).

4.1.1 Households survey

A representative sample survey in all study villages was carried out. The questionnaire was partly developed using qualitative information generated with focus groups. The survey elicited information on households characteristics such as family size and composition, on- and off-farm labor allocation, crops and maize varieties planted, animal holding, consumption and marketing of maize, and an inventory of household land ownership with detailed information on field characteristics. Sub-samples of plots were randomly selected from data on land ownership and information was gathered on their specific management.

The survey was carried out during October and December 2001 from 325 households. The survey was carried by gender, i.e., one section for men and other section for women. The households had a total of 504 farms plots. Farmer's plots are spatially distributed across different slope classes, soil types, moisture regimes and distance from residence. In each community, a random sample of 27 households was drawn from all households involved in agriculture and planting maize. Since the sample size was equal across villages and the number of farming households varied, the sampling fraction varied by villages.

4.1.2 Focus groups

Technical focus groups[14] were held in all 12-study villages mainly on technical issues regarding farmer's perception of maize traits and how they respond to their different needs, priorities, livelihood strategies, and vulnerability context. The following set of issues were discussed in each session: (a) local taxonomy of maize varieties, their characteristics and history; (b) maize varieties that have been abandoned and reasons for their loss; (c) seed management practices; (d) local knowledge of maize reproduction and improvement; (e) local soil taxonomy; (f) the relationship between maize varieties with soil types and with wealth ranking; (g) wealth ranking; and (h) inventory of productive activities in the villages.

4.1.3 Villages and region characteristics

The twelve villages included in the study were located in two highly contrasting regions: the Coast of Oaxaca and Frailesca of Chiapas (Figure 4.2). The names of each the villages was listed. The villages in Frailesca have better access to government provided services and infrastructure even for a similar marginality level than those at the Coast. Productive activities are more oriented to the market and the region has received strong support from state and national governments, particularly for agricultural development. This region produces important maize surpluses that are exported to other parts of Mexico, however agriculture is still dominated by small-scale farmers that produce both for the market and for their own consumption. There is an important dairy industry and farmer can also use maize as animal feed, which is an additional benefit. The use of inputs and improved seed has been promoted through several government projects.

In contrast, Coast of Oaxaca had been more isolated and had not received much government support for agricultural development. The state of Oaxaca imports substantial amounts of maize from other parts of Mexico and from outside (Bellon et al., 2003). Although the Coast of Oaxaca has better climate for maize and agricultural production than other regions of the state, it is not an important producer of this staple.

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[14] All the focus groups were also carried out based on gender, i.e., one for men and one for women to facilitate comfort and collaboration among participants.

Commercial agricultural activities are more biased towards extensive cattle ranching and maize production for home consumption. Development has been more related to tourism, particularly in the coast of the study area, where there are resorts such as Puerto-Escondido, Puerto Angel, and Bahías of Huatulco, among others.

Figure 4.2: Map of the villages included in this study

Villages name	
Coast of Oaxaca	*La Frailesca, Chiapas*
1. Santa María Cortíjos	7. Libertad Melchor Ocampo
2. San Pedro Jicayan	8. Primero de Mayo
3. Santiago Jocotepec	9. Roblada Grande
4. Santa María Magdalena Tiltepec	10. Dolores Jaltenango
5. Santos Reyes Nopala	11. Querétaro
6. San Pedro Mixtepec	12. Rizo de Oro

Source: Bellon et al. (2006)

4.2 Summary statistics from the survey data

4.2.1 Land endowment and area planted with maize by type

Maize, as the principal crop, the principal staple in the diet, is the focus of the data summary presented in this section. Both regions are highly contrasting in terms of area planted with maize as shown in Table 4.1. An ANOVA test was carried out and results show that there are statistically significant differences between regions, i.e., the average area planted with maize is statistically different.

Table 4.1: Land ownership and area planted with maize type (in both regions)

Area (ha)	Oaxaca N = 163			Chiapas N = 162		
	Sum	Mean	Std. Dev.	Sum	Mean	Std. Dev.
Farm Size (total)	1607.25	9.86	14.25	1714.50	10.58	9.26
Animal	799.50	4.90	12.29	230.50	1.42	4.90
Forest	134.00	0.82	4.68	239.50	1.48	4.74
Agricultural	668.00	4.10	5.74	1231.50	7.60	6.66
Maize	182.28	1.12	1.30	816.55	5.04	3.87
Hybrid	6.55	0.04	0.17	285.35	1.76	3.20
OPV	1.10	0.01	0.07	123.05	0.76	1.74
Creolized	57.95	0.36	1.29	130.00	0.80	1.67
Landrace	116.68	0.72	0.73	278.15	1.72	3.19

Source: Survey data

Before describing the results, it is to worthwhile point out that the area planted with maize was corrected according to international plant density standard, where the optimal seeding rate ranging from 45,000 to 65,000 plants per ha (typically around 1 kg equivalent to 3,000 seeds) (Agrawal et al., 1998; Pandey, 1998). In other words, 1 ha corresponds to 20 kg of maize seed. According to Table 4.1 the land ownership by region, Chiapas has more extension than Oaxaca. Small-scale farmers in Chiapas plant at least four times more area with maize than farmers in Oaxaca. The average area planted with maize by farmers in Chiapas is approximately five times bigger than farmers in Oaxaca. The extension of maize adoption is quite different among regions; the farmers in Chiapas plant approximately 540 hectares with modern maize varieties, while farmers in Oaxaca cultivate roughly 66 hectares. In Oaxaca approximately two-thirds of maize area is planted with landraces.

Maize adoption is a key issue in this study; Table 4.2 shows the land endowment for maize adopter and non-adopter farmers in Chiapas. Maize adopter farmers have on average 11 ha of land endowment, while non-adopters 8.7 ha. Regarding to area planted with maize, maize adopter farmers plant 5.21 ha on average, while non-adopters cultivate 4.36 ha on average.

Table 4.2: Land ownership and maize adoption in Chiapas

Area (ha)	Non-Adopter N = 32			Adopter N = 130		
	Sum	Mean	Std. Dev.	Sum	Mean	Std. Dev.
Farm Size (total)	278.50	8.70	7.14	1436.00	11.05	9.68
Animal	208.50	6.52	5.32	1023.00	7.87	6.94
Forest	30.00	0.94	3.16	200.50	1.54	5.24
Agricultural	30.00	0.94	3.37	209.50	1.61	5.03
Maize	139.55	4.36	3.15	677.00	5.21	4.03
Hybrid	0.00	0.00	0.00	285.35	2.20	3.43
OPV	0.00	0.00	0.00	123.05	0.95	1.90
Creolized	0.00	0.00	0.00	130.00	1.00	1.81
Landrace	139.55	4.36	3.15	138.60	1.07	2.85

Source: Survey data

Poverty is another important point in this study; Table 4.3 shows the relationship between poor and non-poor farmers in Chiapas, where poor farmers plant approximately 43% of total maize area with landraces, while non-poor farmers cultivate roughly 25% of total maize area with landraces.

Table 4.3: Land ownership and poverty in Chiapas

Area (ha)	Non-Poor N = 87			Poor N = 75		
	Sum	Mean	Std. Dev.	Sum	Mean	Std. Dev.
Farm Size (total)	980.50	11.27	8.83	734.00	9.79	9.74
Animal	723.00	8.31	7.68	508.50	6.78	5.15
Forest	140.00	1.61	4.21	90.50	1.21	5.61
Agricultural	112.00	1.29	3.71	127.50	1.70	5.74
Maize	434.85	5.00	4.18	381.70	5.09	3.52
Hybrid	192.40	2.21	3.87	92.95	1.24	2.07
OPV	41.75	0.48	1.39	81.30	1.08	2.04
Creolized	86.75	1.00	1.78	43.25	0.58	1.50
Landrace	113.95	1.31	3.12	164.20	2.19	3.22

Source: Survey data

Maize adoption area in Oaxaca has different pattern. Table 4.4 shows the land endowment by maize adoption criteria. The average area planted with maize is roughly 1.4 ha for maize adopter farmers, whereas 0.97 ha on average for non-adopters. However, the total land endowment is at least two times bigger for non-adopter than maize adopters. It appears that non-adopters probably allow more area to animals, other crops or forests as is shown in Table 4.4.

Table 4.4: Land ownership and adoption in Oaxaca

Area (ha)	Non-Adopter N = 111			Adopter N = 52		
	Sum	Mean	Std. Dev.	Sum	Mean	Std. Dev.
Farm Size (total)	1018.75	9.18	13.20	588.50	11.32	16.30
Animal	505.50	4.55	10.60	294.00	5.65	15.38
Forest	103.00	0.93	4.92	31.00	0.60	4.16
Agricultural	405.50	3.65	4.71	262.50	5.05	7.44
Maize	107.53	0.97	0.72	74.75	1.44	2.02
Hybrid	0.00	0.00	0.00	6.55	0.13	0.29
OPV	0.00	0.00	0.00	1.10	0.02	0.13
Creolized	0.00	0.00	0.00	57.95	1.11	2.11
Landrace	107.53	0.97	0.72	9.15	0.18	0.35

Source: Survey data

The differences between poor and non-poor farmers and land endowment for Oaxaca are presented in Table 4.5. Whereas poor farmers plant roughly 77% of total maize area with landraces, non-poor farmers cultivate about 49% of total maize area with landraces. Surprisingly both groups of farmers (poor and non-poor) have the same land endowment (see sum column), but on average poor farmers have 8.4 ha, while non-poor farmers have 12 ha on average.

Table 4.5: Land ownership and poverty in Oaxaca

Area (ha)	Non-Poor N = 67			Poor N = 96		
	Sum	Mean	Std. Dev.	Sum	Mean	Std. Dev.
Farm Size (total)	803.75	12.00	17.69	803.50	8.37	11.10
Animal	540.00	8.06	17.53	259.50	2.70	5.67
Forest	19.00	0.28	0.97	115.00	1.20	6.03
Agricultural	242.50	3.62	3.41	425.50	4.43	6.91
Maize	86.55	1.29	1.88	95.73	1.00	0.62
Hybrid	3.05	0.05	0.20	3.50	0.04	0.15
OPV	0.00	0.00	0.00	1.10	0.01	0.09
Creolized	40.80	0.61	1.92	17.15	0.18	0.44
Landrace	42.70	0.64	0.78	73.98	0.77	0.68

Source: Survey data

Ethnicity and land endowment is another key issue in this study. The relationship among indigenous and non-indigenous farmers and land ownership is presented in Table 4.6. Whereas non-indigenous farmers have at least 3 times more land endowment than indigenous farmers, it is important to highlight that the number of indigenous farmers is around 50% of the total interviewed households. Regarding the area planted with maize, non-indigenous farmers have two times more area planted under maize than indigenous farmers. Indigenous farmers plant roughly fourth-fifths of the maize area with landraces, while non-indigenous plant approximately a half part of the maize area with landraces.

Table 4.6: Land ownership and ethnicity in Oaxaca

Area (ha)	Indigenous N = 80			Non-Indigenous N = 83		
	Sum	Mean	Std. Dev.	Sum	Mean	Std. Dev.
Farm Size (total)	391.75	4.90	5.94	1215.50	14.64	17.89
Animal	147.50	1.84	5.21	652.00	7.86	15.95
Forest	18.00	0.23	0.94	116.00	1.40	6.46
Agricultural	221.50	2.77	2.62	446.50	5.38	7.42
Maize	74.58	0.93	0.45	107.71	1.30	1.75
Hybrid	1.60	0.02	0.13	4.95	0.06	0.21
OPV	0.20	0.00	0.02	0.90	0.01	0.10
Creolized	11.00	0.14	0.42	46.95	0.57	1.74
Landrace	61.78	0.77	0.45	54.91	0.66	0.91

Source: Survey data

4.2.2 Maize prices

Farmers in both Chiapas and Oaxaca distinguished between kernels as grain and maize kernels as seed, although from biological perspective they are the same. In farmer–to–farmer seed transactions, kernels for seed and grain show important price differentials. For example, landraces seed cost MX$ 3.88 per kilo and MX$ 3.51 per kilo in Oaxaca and Chiapas, respectively, whereas landrace grain cost MX$ 2.41 and MX$ 1.82, respectively.

Regarding the improved seed in Oaxaca, hybrid seed cost on average MX$ 17.44 per kilogram. Creolized seed cost on average MX$ 5.33 per kilogram. In Chiapas the price of Creolized seed is on average MX$ 6.33, and the hybrid seed on average MX$ 20.25 per kilogram. This suggests that farmers are willing to pay a premium for creolized varieties over landraces in both regions.

4.2.3 Maize sample collection

Farmers in both study areas plant numerous maize varieties ranging from hybrids to landraces. All of the maize-types recognized by the farmers were collected in the 12 villages. A total of 126 maize samples were collected, each representing a distinct maize type recognized by farmers at community level. Forty maize ears per type were collected at random from the harvest pile of ears at the home of the farmer. One expert-research of maize taxonomy of the INIFAP genebank classified each maize ear by racial category or group. And samples of available commercial varieties (Hybrids and OPVs) were also collected and classified.

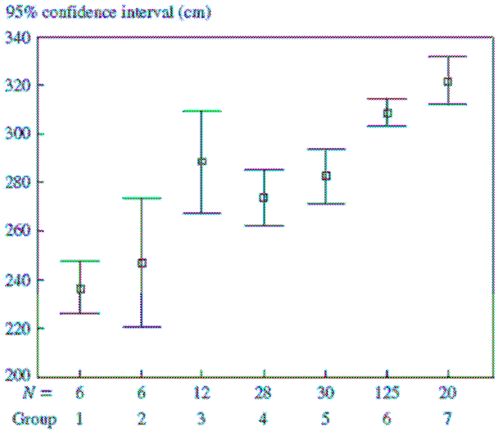
The interviewers also elicited extensive information on the varieties planted (see the questioners in Appendix B), their names, origin, history, and management. Maize variety classification was achieved from the survey information into four categories: hybrids, OPV, creolized and landraces. The classification is based on (1) the name provided by the farmer, (2) whether the farmer said that the seed came from a "bag", (3) the number of years seed was used, (4) information on its origin from the farmer and focus group discussions, and (5) classification by a maize taxonomist of a collection of maize samples from all communities in the study. Table 5.2 below presents the specific criteria used for each category. Classifying the maize types elicited from farmers in the survey entails a certain degree of arbitrariness. As Morris, Risopoulos, and Beck (1999) note, the dynamic nature of maize makes classifying its varieties into distinct and well-defined categories difficult and somewhat arbitrary, However, the study classification is useful as long as the criteria are workable, defensible, and consistent (Bellon et al., 2007). This classification is the basis for the adoption, conservation and causal-effect analyses presented below.

The 126 samples of maize collected were evaluated for agronomic characteristics at the INIFAP *Cotaxtla* Experimental Station in eastern Mexico, together with three commercially purchased improved OPVs and nine landraces accessions from the CIMMYT gene-bank as controls, more details in Bellon et al. (2007).

There are statistically significant differences among the groups, as well as clear trends. These results support the idea that the maize type classification is biologically meaningful.

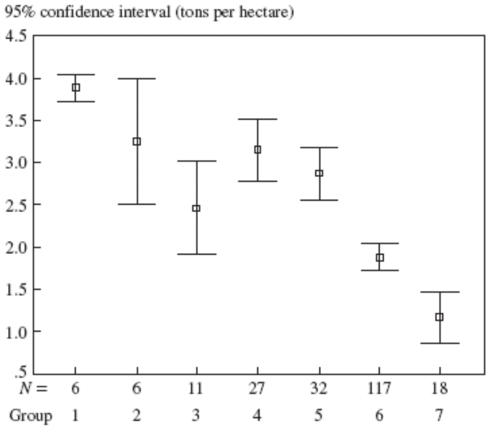
The Figures 4.3a and 4.3b show that the classification is able to capture measurable and statistically significant differences and trends in the key plant characteristics. Average plant height increases while yield decreases as one moves from the groups classified as hybrids to those classified as landraces. The control groups are at the extremes.

Figure 4.3a: Plant height



Source Bellon et al. (2007)

Figure 4.3b: Maize yield



Source Bellon et al. (2007)

The trends in the data are consistent with what one may expect with the maize populations resulting from scientific breeding–they have shorter plant height and high yields, compared to populations that have been under long-term farmer management (landrace and creolized varieties).

Notes: Data are from maize samples collected in the study sites and classified according to criteria in Table 5.2 below. Group 1 refers to seed of a set of three commercial OPV purchased in a commercial outlet. Groups 2–6 refers to the seed of the 126 varieties collected in the field site and classified according to criteria in Table 5.2 as: hybrid (group 2), recycled hybrid (group 3); OPV (group 4); creolized varieties (group 5); and landrace (group 6). Group 7 refers to a set of nine representative accessions of landraces from the region obtained from the CIMMYT genebank. Groups 1 and 7 are the controls referred previously.

Chapter 5

Estimation and econometric issues

Given the focus and objectives of this study, three different econometric techniques are employed to analyze the data. The *Probit*-model is used to analyze the factors that contribute to small-scale farmers' maize technology adoption. The *Poisson*-model is employed to study the factors that influence how small-scale farmers maintain traditional maize or local varieties and minor crops varieties like beans and squash into the *Milpa* system. The propensity score matching [PSM] approach (Rosenbaum and Rubin, 1983; Becker and Ichino, 2002; Leuven and Sianesi, 2003) is applied to measure the *causal-effect* of maize technology adoption on poverty alleviation. The PSM approach has recently begun to be employed widely in social and economic studies as a method of evaluating social-programs. The PSM approach is well suited for this dissertation, allowing one to contribute to the discussion of whether maize adoption helps to improve the poorest farmers' livelihood. And the poverty analysis is done using the procedure developed by Foster, Greer and Thorbecke [FGT] (1984).

The chapter has three major sections: Section 5.1 presents the econometric specification for maize adoption for both regions; Section 5.2 presents the econometric issue for maize conservation for Oaxaca; and section 5.3 shows the propensity score matching method for maize adoption and poverty overhauling the *causal-effect* for Chiapas and Oaxaca.

5.1 Probit-model regression for adoption

Adoption is modeled following the random utility framework proposed by Mcfadden (1981). The reduced form of the household model from Chapter 3, sections 3.1 and 3.2, adapted from van-Dusen (2006) is: $W(\Psi_{HH}, \Psi_{Farm}, \Psi_{Gprogram})$. Let $W_j^c(\Psi)$ denote the household's maximum utility, given the constraint represented by 3.2 and 3.3 (in Chapter 3), if the household participates in activity (adoption) j, and let $W_{-j}^C(\Psi)$ denote maximum welfare constraint. Both $W_j^c(\Psi)$ and $W_{-j}^C(\Psi)$ assume optimal choices of $Q_j\forall, L_j$, and X in the random utility model $W_j^c(\Psi)=\overline{W}_j^C(\Psi)+\varepsilon_j$, and $W_{-j}^c(\Psi)=\overline{W}_{-j}^C(\Psi)+\varepsilon_{-j}$. The households chooses to participate (adopt) in activity (improved germplasm) j if $\overline{W}_j^C(\Psi)+\varepsilon_j>\overline{W}_{-j}^C(\Psi)+\varepsilon_{-j}$ or $\overline{W}_j^C(\Psi)-\overline{W}_{-j}^C(\Psi)>\varepsilon_{-j}-\varepsilon_j$. The solution to this set of J adoption decision yields a set of optimal adoption choices I*(Z), where the probability of observing a household's participation in activity (adoption of particular improved germplasm) j is given by:

$$
\begin{aligned}
&\Pr(j)=\Pr(I_j^*=1)\\
&=\Pr(W_j^C(\Psi)>W_{-j}^C(\Psi))\\
&H(\overline{W}_j^C(\Psi)-W_{-j}^C(\Psi)>\varepsilon_{-j}-\varepsilon_j) \qquad (5.1)
\end{aligned}
$$

if the errors, ε_j are each normally distributed with mean zero and constant σ_ε^2, $H(\cdot)$ is the normal cumulative distribution function, and the model given in equation (3.17) Section 3.2 (above) can be estimated by *Probit*-model for adoption of improved germplasm.

The random-utility model is appropriate for a single choice (e.g. whether or not to adopt a given germplasm). However, the objective of this analysis calls for modeling the maize adoption in which the households choose to adopt (e.g. if the farmer use improved germplasm, which is the measure of technology adoption). Unordered-choice model can be motivated by random utility model. For the *i*-th farmer faced with *j* choices (Greene, 2003).

5.1.1 Dependent variable for the *Probit-model*

Farmers in Chiapas and Oaxaca can select between 4 possible maize types [MT], i.e., MT = (hybrid, OPV, creolized, and landrace)[15]. For each MT the farmers make a discrete-choice (Figure 5.1) or each farmer makes a personal MT combination among the germplasm available, obviously looking for his or her utility maximization. Then an adoption decision by farmers is inherently a multivariate decision. Table 5.1 shows the empirical maize type choices and combinations for both regions, indicating that there is

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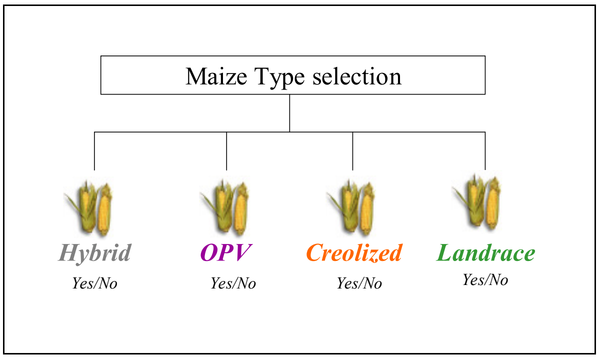
[15] Maize variety classification is presented in Table 5.2 below.

a spectrum of maize types and combinations among them, i.e., many farmers make a portfolio of selected maize types.

Figure 5.1: Maize type selection by farmers



Therefore, it is appropriate to treat adoption of maize type as a multiple-choice decision. For the binary probit-model specification, a maize adopting farmer is considered as one who uses any modern variety like hybrid, OPV or creolized, taking the value 1 (this category can collapse into a single group because these three maize types contain improved germplasm, grouping them in one category is reasonable because in general the seeds have been derived from formal breeding programs). And a maize non-adopting farmer is considered as one that uses no modern variety, i.e., plant only maize landrace varieties, taking the value 0.

The farmer's utility of choosing a specific MT is not observable but his selection is observed. If the farmer's choice is the *i*-th alternative among a set of *N* alternatives, then we assume that utility from the *i*-th alternative is the maximum among the *N* alternatives. Therefore alternative *i* is chosen:

if and only if $U_{MT} = \max(u_i^* \cdots u_N^*)$

for all $U_{MT_i} > U_{MT_j}$, also $i \neq j$

Suppose that the utility of *i*-th selection is:

$$U_{MT}^* = \phi'_{MT_i} Z_{MT_i} + \varepsilon_{MT_i} \tag{5.2}$$

Multinomial-Logit and Ordered Probit models could be suitable techniques, but both methods could not generate meaningful results. Detail of the results and procedures is presented in Appendix A.1 and A.2. The Multinomial-Logit failed because there is insufficient variation in the dependent variable for 13 of the 16 categories (removing the

MT's combinations 8, 9, and 16 from Table 5.1). The results from Ordered-Probit do not make economic sense, since the major assumption is the consideration of maize type as ordered class, where maize hybrid is ranked better than maize landraces. In reality, maize landraces and creolized varieties have attributes that farmers value more than maize hybrid or OPVs (Bellon, et. al., 2006).

Table 5.1: All maize types choice and combinations by farmers

MT combinations		Frequency (a)			
		Chiapas	%	Oaxaca	%
1	Hybrid	33.0	20.4	4.0	2.5
2	Hybrid & Landrace	19.0	11.7	7.0	4.3
3	Hybrid & Creolized	10.0	6.2	-	-
4	Hybrid, Creolized & Landrace	3.0	1.9	-	-
5	Hybrid & OPV	8.0	4.9	-	-
6	Hybrid, OPV & Landrace	3.0	1.9	-	-
7	Hybrid, OPV & Creolized	1.0	0.6	-	-
8	All	-	-	-	-
9	Nothing	-	-	-	-
10	Landrace	32.0	19.8	111.0	68.1
11	Creolized	22.0	13.6	30.0	18.4
12	Creolized & Landrace	2.0	1.2	9.0	5.5
13	OPV	23.0	14.2	2.0	1.2
14	OPV & Landrace	3.0	1.9	-	-
15	OPV & Creolized	3.0	1.9	-	-
16	OPV, Creolized & Landrace	-	-	-	-
(a) Number of Household-farm		N=162	100	N=163	100

Source: Survey data

For Oaxaca region a Poisson-model is suitable, where approximately 70% of farm households cultivate maize landraces varieties. These empirical results support the research and development interventions for maize diversity conservation (the model specification details are in Section 5.2).

Lastly, in this research the maize type classification is based on: (1) the name provided by the farmer, (2) whether the farmer responded that the seed came from a "bag," (3) the number of years seed was used, (4) information on its origin from the farmer and focus group discussions and (5) classification by a maize taxonomist of a collection of maize samples from all communities in the study area. Table 5.2 presents the specific criteria used for each category.

Table 5.2: Criteria used to classify farmer-identified varieties into four categories

Category	Criteria
Maize hybrid	▪ Name provided by farmer of a known hybrid ▪ Seed came from a "bag" and first year of planting (F1) ▪ Focus group identified the name as being introduced to the community by government or commercial outlet ▪ Maize taxonomist indicated that sample with same name was of a hybrid or recycled hybrid ▪ If farmer had planted the seed from the previous harvest up to four years (F4)
Maize Open Pollinated Variety	▪ Idem, but name provided by the farmer was from a known OPV ▪ Seed had been planted for the first (F1) time or recycled up to four years (F4)
Maize Creolized	▪ Any of the above, but farmer had recycled the seed for more than four years and up to fifteen
Maize Landrace	▪ Named provided by farmer of a known maize race (e.g. *Zapalote*, *Tepecente*, *Olotillo*) ▪ It did not have a specific name (*maiz blanco*) but had been planted for many years either by the farmer or somebody else in the community ▪ It did not come from a bag ▪ Focus group identified the name as a local variety ▪ Maize taxonomist indicated that the sample with the same name was a landrace

Source: Bellon et al. (2003)

5.1.2 Explanatory variables for the *Probit*-model

The variables are divided into three groups. The groups of variables are households characteristics Ψ_{HH}, farm characteristics Ψ_{Farm} and government program characteristics $\Psi_{Gprogram}$. The summary statistics for each set of explanatory variables are presented in Tables 5.3, 5.4, and 5.5 respectively. The first set of variables are those that describe the household (Table 5.3).

Table 5.3: Households characteristics for Chiapas (for Probit model)

Variable name	Variable description	Mean		Std. Dev.		Min		Max	
		NA	A	NA	A	NA	A	NA	A
AGE	Age in years of the household head	52.03	47.83	17.34	13.49	25	20	96	78
EDUDUMY	1 if the farmer head has an education	0.53	0.81	0.51	0.40	0	0	1	1
HHSIZE	Number of people residing in household	6.03	5.14	2.35	2.23	2	2	10	13
SHAM1550	Share of male between >15 & <50 years	10.88	12.71	11.90	14.89	0	0	38	57
STAPLEC	Number of staple crops	1.38	0.74	1.70	1.02	0	0	8	5
HORSE	Number of horse owned by household	0.41	0.67	0.71	0.97	0	0	2	6
REMITTAN	1 if HH received remittance from abroad	0.06	0.14	0.25	0.36	0	0	1	1
DISTANCE	Distance to the permanent market (Km)	31.91	29.95	23.53	18.49	6	6	57	57

NA = Non-Adopters n=32; A = Adopters n=130. Source: Survey data

The first variable is age, and it is measured by the farm householder head's number of years since birth. Age is included in order to look at whether young farmers are the ones adopting maize technology because of new knowledge or skills are required. The sign for age is expected to be negative if old farmers are non-adopters of maize technology.

Education. According to Abdulai and Huffman (2005), more efficient adoption decisions could result in more educated farmers adopting the technology either earlier or later. Human capital variables are expected to increase the probability of farmers making economically correct adoption decision. Following human capital theory, allocative skills are assumed to be acquired or learned rather than inherited. In particular, farmers' investments in schooling, experience, information, and health are expected to enhance allocative skills and to increase the efficiency of adoption decisions (Rahm and Huffman, 1984).

Furthermore, Doss and Morris (2001) and Gamba et al. (2002) showed that education is significant in determining farmer's ability to understand and manage unfamiliar technology. Gamba et al. (2002) found that education contributes to general awareness and favors adoption of new varieties in five districts of Kenya.

Doss (2003) argued that there is a big difference between farmers who are educated and those who are not. The difference between five and six years of education may have much less impact on the adoption of improved technologies than the difference between three and four years of education. She pointed out that dummy variable for education might be a better measure (1 if the head farmer has an education, 0 otherwise). Finally, the farmer's age and level of education are human capital variables frequently used as proxies to indicate the ability to acquire and process information (Dimara and Skuras, 2003).

Family Size: The family size might affect maize variety choice via households labor supply decisions (Doss, 2003; Hintze et al., 2003). Also Lee (2005), Bekele and Drake (2003), and Bellon and Risopolous (2001) argued that a large family size is generally associated with a greater labor force available to the household for timely operation of activities including adoption of new technology.

The share of male household members (between 15-50 years old). The share of male members is expected to positively affect the maize technology adoption, this variable represent the manpower availability, and usually the new technology is labor intensive. Bellon and Risopoulos (2001) findings demonstrate that farmers perceived that modern varieties are management intensive, meaning that modern varieties requires timely weeding and application of inputs lest their yield advantage be lost. According to their findings, farmers referred to modern varieties as a "delicate variety" and farmers considered it appropriate for those that could afford to mobilize labor and purchase inputs in timely fashion.

Number of staple-crops. The sign of this variable is expected to be negative if minor varieties of crops like beans, squash and chili are intercropped as in *Milpa*-system, because *Milpa*-system is linked with maize landraces (Bellon and Brush, 1994; Brush, 1995; van Dusen, 2000). If the farmers inter-plant staple crops this reduces the likelihood of maize technology adoption. Usually modern maize varieties are planted alone as mono-cropped in high-density population (plant by area). Heisey et al. (1998) argue that a critical factor in determining the attractiveness of improved germplasm is the yield advantage compared with local varieties. One important factor, among others, in determining the profitability of switching to improved germplasm is the seed rate.

The seed rate for monocropped maize typically is in the rage of 20 or 25 kg/ha of seed. Obviously, inter plant minor crops (beans and squash) reduce the seed rate, and consequently yield per hectare.

Number of Horses. A horse is generally considered to be an asset that could be used either in the production process, transportation or traction potential. The sign of this variable is expected to be positive if the farmer has horses (as capital) contribute to maize adoption. Bekele and Drake (2003) found two things: first, all livestock is considered as a measure of wealth and increased availability of capital which make investment in conservation more feasible. Secondly, livestock, particularly oxen, are used as working assets to perform farm operations, including new technology, which increases the possibility for timeless effects. In Mexico a horse is used in the production process, transportation and traction potential (Dagoberto Flores, personal communication).

Remittances are measured as the money or income that is received by the household as transference from abroad. The variable is a dummy, 1 if the household received and 0 otherwise. The sign of this variable is expected to be positive; if the farmer's household receives remittances this could be used to tackle the cash constraint. Brush and Chauvet (2004: 45-46) point out that the cultural identities of social groups have different ways of expressing themselves in face of modern processes; these may be assimilation, transculturation, recreation or resistance. In some rural communities, identities that have been constructed over many generations suffer a process of rupture as a result of migration, above all, if migration becomes permanent. The Mexican migrants help sustain their native villages with money, electronic devices, and the cultural influences of the American. The repercussions of migration on agriculture practices are complex. On one hand, young men and women leave their villages to subsist or find better options for their lives and maize cultivation is abandoned, and, on the other hand, migrants send money that is invested in the planting of maize, among other things. Migration is likely to have contributed to loss of genetic diversity, but probably contributes to buy maize improvements. The remittances coefficient sign is expected to be positive for maize technology adoption, and negative for maize biodiversity conservation (for poisson model specification Section 5.2 below).

Distance. The distance between a community and a key nodal town is included as indicator of potential linkages to the regional and national economies. The underlying rationale is that farmers in communities closer to a key town can more easily interact with the regional national economies, since transportation costs are probably lower. They are also more likely to plant improved varieties, while those farther away may have to rely more on landraces. Abdulai and Huffman (2005) confirm that households located closer to markets are more likely to adopt new agricultural technologies than their counterparts located in isolated areas, as measure of transaction costs.

Table 5.4: Farm characteristics for Chiapas (for Probit model)

Variable name	Variable description	Mean		Std. Dev.		Min		Max	
		NA	A	NA	A	NA	A	NA	A
LANDOWNER	1 if the farmer is landlord	0.81	0.92	0.40	0.27	0	0	1	1
NUMPLOTS	Number of plots	2.03	1.96	1.09	1.07	1	1	5	5
AREAMAIZ	Area planted with maize (ha)	4.36	5.21	3.15	4.03	0.75	0.6	15	28
ARED	Area with red soil (ha)	0.59	0.67	1.60	1.78	0	0	6	13
SLOPE	Slope area (ha)	0.66	0.40	0.48	0.49	0	0	1	1

NA = Non-Adopters n=32; A = Adopters n=130. Source: Survey data

Land ownership. The land ownership is a source of wealth, consequently larger land holdings will affect adoption decision positively (Doss, 2003; Abdulai and Binder, 2006). The sign of land ownership is expected to be positive if the farmer is the owner of the plot and positively affects technology adoption.

Number of Plots. The number of plots is expected to have negative influence on maize technology adoption. Bellon and Taylor (1993) findings suggested that fragmentation of land holdings is negatively associated with the area planted in modern varieties, if the farmer has many plots imply that the farmer has to invest more time, inputs and resources in care of each plot.

Area planted with Maize. Larger farm sizes are associated with greater wealth and increased availability of capital, which make investment in new maize varieties like hybrid or OPV possible. Doss and Morris (2001) and Gamba et al. (2002) found that farmers with larger farm sizes are more likely to be able to afford fertilizer and modern varieties.

Area Red (soil quality). This variable is expected to be positive; farmers interviewed in the focus group discussion ranked area red among highest quality soils in the region. Bellon and Tylor (1993) found that modern varieties are allocated on higher quality lands where these varieties are likely to perform optimally.

Slope of Plot. Feder and Umali (1993) pointed out in their review that the agro-climatic environment is the most significant determinant of allocation for differences in adoption rate. The slope of the field is expected to be negative, since in sloppy field there is less density of the number of plants per hectare than flat fields (Julian Berthaud, personal communication).

Table 5.5: Government programs for Chiapas (for Probit model)

Variable name	Variable description	Mean		Std. Dev.		Min		Max	
		NA	A	NA	A	NA	A	NA	A
SUBSIDY	Government subsidy: *PROCAMPO*	0.84	0.84	0.37	0.37	0	0	1	1
SEEDX	Government MV-Seed exchange program	0.16	0.41	0.37	0.49	0	0	1	1
ACCESEXT	if the farmer got information (extension)	0.22	0.50	0.42	0.83	0	0	1	4

NA = Non-Adopters n=32; A = Adopters n=130. Source: Survey data

Participation in government programs is an important way for farmers to link up with the regional and national economies. These programs provide farmers with inputs, financing, and specialized knowledge, and probably influence farmers' planting decisions. *PROCAMPO* and *Kilo por Kilo* were two important government programs in the last domestic agricultural reforms in Mexico.

PROCAMPO (*Programa de Apoyos Directos al Campo*) is a government subsidy program. The Secretary of Agriculture provides this cash transfer to farmers who produce any of the following crops: maize, beans, wheat, rice, soy and cotton. The farming area (number of hectares) determines the amount of the cash transfer, which ranges from MX$ 700 to MX$ 800 *pesos* per hectare depending on the season 2000 (Skoufias, 2005). This subsidy is expected to be positive if the cash transfer contributes to the technology change.

Kilo por Kilo. (Kilogram by kilogram) this is another government program promoting the technological change among small-scale farmers (< 20 hectares), through the diffusion and interchange of modern maize seed varieties with traditional varieties. The coefficient's sign is expected to be positive, indicating the effectiveness of the technology transfer.

Access to Information and Advice. Contact with extension agents is expected to have a positive effect on adoption based upon the innovation-diffusion theory. Such contacts, by exposing farmers to availability of information can be expected to stimulate adoption (Adesina and Zinnah, 1993; Doss, 2003). Also Abdulai and Huffman (2005) argued that adoption of a new technology might also be influenced by the visits of agricultural extension workers to farmers. In most developing countries, agricultural extension tends to be a major source of information on technological improvements in the agricultural sector. Sunding and Zilberman (2001) argue that various types of extension programs reduce the risk associated with performance and the appropriateness of new technologies is addressed by arrangements such as money-back guaranties. Additionally, they point out that many of the marketing strategies, including warranties, money-back guarantees, and demonstrations are part of businesses by agricultural firms.

For Oaxaca the group of variables corresponding to households characteristics Ψ_{HH}, Farm characteristics Ψ_{Farm} and Government program characteristics $\Psi_{Gprogram}$ are presented in Tables 5.6, 5.7, and 5.8 respectively. Most of these variables are exactly the same as used and presented in Chiapas, only two new variables are included in Oaxaca; the main argument is that both regions are substantially different in social aspects, particularly in Oaxaca approximately 50% of households interviewed are indigenous.

Table 5.6: Households characteristics for Oaxaca (for Probit model)

Variable name	Variable description	Mean		Std. Dev.		Min		Max	
		NA	A	NA	A	NA	A	NA	A
AGE	Age in years of the household head	49.95	51.12	14.07	13.43	19	28	80	80
EDUDUMY	1 if the farmer head has an education	0.71	0.79	0.46	0.41	0	0	1	1
ETHNICTY	1 if the farmer head is Non-Indigenous	0.41	0.71	0.49	0.46	0	0	1	1
HHSIZE	Number of people residing in household	5.83	5.52	2.64	2.36	2	2	16	12
SHAM1550	Share of male >15 & <50 years	11.73	17.06	13.85	15.29	0	0	50	50
STAPLEC	Number of staple crops	0.51	0.44	0.86	0.92	0	0	4	4
HORSE	Number of horse owned by household	0.35	1.13	0.82	1.83	0	0	4	10
REMITTAN	1 if the Hh received remittances from abroad	0.03	0.08	0.16	0.27	0	0	1	1
DISTANCE	Distance to the permanent market (Km)	43.17	33.14	21.01	21.05	16.5	16.5	69	69

NA = Non-Adopters, n=111; A = Adopters, n=52. Source: Survey data

Ethnicity: (is one of the two new variables) this variable captures the racial difference among farmers, i.e., indigenous or non-indigenous farmers. For instance, an indigenous farmer is an indicator of cultural identity and ability to interact with the regional and national economies. Indigenous farmers are more likely to attach stronger cultural values to maize consumption than non-indigenous farmers; hence, they may prefer to plant maize landraces rather than improved varieties. On the other hand, non-indigenous farmers or Spanish speakers may interact better with the regional and national economy and, hence, be more interested in growing improved varieties. This variable was not included in the adoption regression for Chiapas, where almost all the households speak Spanish or are non-indigenous and there is a longer history of integration into the national culture and economy than in Oaxaca (Bellon et al., 2005).

Table 5.7: Farm characteristics for Oaxaca (for Probit model)

Variable name	Variable description	Mean		Std. Dev.		Min		Max	
		NA	A	NA	A	NA	A	NA	A
LANDOWNER	1 if the farmer is landlord	0.80	0.85	0.40	0.36	0	0	1	1
NUMPLOTS	Number of plots	1.10	1.19	0.38	0.49	1	1	3	3
AREAMAIZ	Area planted with maize (ha)	0.97	1.44	0.72	2.02	0.1	0.2	5.6	15
REDSOIL	1 if the plot has red soil	0.12	0.21	0.32	0.41	0	0	1	1
SLOPE	1 if the plot is slope	0.75	0.69	0.44	0.47	0	0	1	1
GOOD	1 if the plot has good soil quality	0.59	0.69	0.49	0.47	0	0	1	1

NA = Non-Adopters, n=111; A = Adopters, n=52. Source: Survey data

Good Soil Quality (the second of the new variables) land quality (good quality as a measure of productivity) is the most important determinant of adoption (Feder and Umali, 1993). This variable was included in this model because indigenous farmers have different perceptions about the land, i.e., the perceptions on land quality differ between the indigenous and non-indigenous. For indigenous farmers, land implies full enjoyment; they believe that land offer all their livelihood and foods. Indigenous farmers always opine with respect about land. Therefore, the coefficient's sign of good quality soil is expected to be positive; if a farm has good soil quality is very likely to contribute to modern maize varieties adoption.

The last set of variables, government program characteristics, has been explained in the previous section, for Chiapas region.

Table 5.8: Government programs for Oaxaca (for Probit model)

Variable name	Variable description	Mean		Std. Dev.		Min		Max	
		NA	A	NA	A	NA	A	NA	A
SUBSIDY	Government subsidy: PROCAMPO	0.73	0.75	0.45	0.44	0	0	1	1
SEEDX	Government MV-Seed exchange program	0.22	0.35	0.41	0.48	0	0	1	1
ACCEXTEN	Access extension advice	0.19	0.31	0.39	0.47	0	0	1	1

NA = Non-Adopters, n=111; A = Adopters, n=52. Source: Survey data

5.2 Poisson regression for biodiversity conservation

Conservation will be modeled following the random utility framework proposed by Mcfadden (1981). The reduced form of the household model from Chapter 3, sections 3.1 and 3.3, adapted from van Dusen (2006) is: $W(\Psi_{HH}, \Psi_{Farm}, \Psi_{Gprogram})$. Let $W_j^c(\Psi)$

denote the household's maximum welfare, given the constraints represented by 3.2 and 3.3 (Chapter 3) if the household participate in activity (plant *Milpa*) *j*, and let $W_{-j}^{C}(\Psi)$ denote maximum constraint welfare otherwise. Both $W_{j}^{c}(\Psi)$ and $W_{-j}^{C}(\Psi)$ assume optimal choices of $Q_j \forall, L_j,$ and *X*.

In the random utility model $W_{j}^{c}(\Psi)=\overline{W}_{j}^{C}(\Psi)+\varepsilon_j$, and $W_{-j}^{c}(\Psi)=\overline{W}_{-j}^{C}(\Psi)+\varepsilon_{-j}$. The household chooses to participate (plant Milpa) in activity j if $\overline{W}_{j}^{C}(\Psi)+\varepsilon_j > \overline{W}_{-j}^{C}(\Psi)+\varepsilon_{-j}$ or $\overline{W}_{j}^{C}(\Psi)-\overline{W}_{-j}^{C}(\Psi) > \varepsilon_{-j}-\varepsilon_j$. The solution to this set of *J* cultivation decision yields a set of optimal adoption choices I*(Z), where the probability of observing a household's participation in activity (planting *Milpa*) *j* is given by

$$\begin{aligned}
&\Pr(j)=\Pr(I_j^{*}=1)\\
&=\Pr(W_{j}^{C}(\Psi)>W_{-j}^{C}(\Psi))\\
&H(\overline{W}_{j}^{C}(\Psi)-W_{-j}^{C}(\Psi)>\varepsilon_{-j}-\varepsilon_j) \qquad (5.3)
\end{aligned}$$

if the errors, ε_j are each normally distributed with mean zero and constant σ_{ε}^{2}, $H(\cdot)$ is the normal cumulative distribution function, and the model given in equation (3.18) can be estimated by *Poisson*-model for adoption each maize type.

The reduced form of the theoretical model proposed in Chapter 3 is for the number of crops varieties grown. There are many possible measures of diversity and many levels of human interactions with crop populations. However, planting *Milpa* crops is a basic condition for maintaining diversity (van Dusen, 2000).

The count data model is linked to a random utility specification. The random utility model is appropriate for a single choice (e.g., whether or not to participate in a given activity). However, the objectives of this analysis call for modeling the total number in which the households choose to participate (e.g., the number of varieties grown, which is the measure of diversity). The Poisson model is well suited to this kind of modeling.

The probability of choosing *k* activities given *n* independent trails is represented by the binomial distribution: $P(Y=k)=\left(\frac{n}{k}\right)p^{k}(1-p)^{n-k}$

where $\binom{n}{k} = \frac{n!}{k!(n-k)!}$ and p is the probability of choosing k

From statistical theory a repetition of a series of binomial choices (here, from the random utility formulation) asymptotically converges to a *Poisson* distribution as n becomes large and p becomes small.

$$\lim_{n\to\alpha}\binom{n}{k}p^k(1-p)^{n-k} = \frac{e^{-\lambda}\mu^k}{k!} \tag{5.4}$$

where $p = \mu / n$ and μ is the mean of the distribution (in this case, the mean number of activities per household). This formulation allows one to model the probability that a household chooses a number of activities, *k*, given a parameter μ, the sample mean.

Hellerstein and Mendelsohn (1993) proposed two theoretical linkages between utility theory and a Poisson specification. The first is a demand model for an indivisible good where choice is restricted to be a non-negative integer, which is relevant to a wide range of real consumer choices. The second follows the statistical theory outlined above by modeling a series of discrete consumer decisions that would sum across an aggregation of choices to a Poisson distribution. Thus, the Poisson specification is used to model the increase in utility from one additional unit consumed (Hellerstein and Mendelsohn, 1993).

The count data specification is utilized because of the way it gives the model flexibility to explain total system diversity aggregated across crops as well as within crops. This flexibility allows the explanatory power of the model to move in a diversity space both across varieties and across species. The linking of the behavioral model with an econometric model is therefore consistent with the overall conservation strategy of conserving minor varieties. The count data model makes it possible to compare parameter estimates in a model of total system diversity as well as diversity within each crop (van Dusen, 2000).

The Poisson regression model is the development of the *Poisson* distribution in Equation (5.4) to a nonlinear regression model of the effect of independent variables x_i on a scalar dependent variable y_i. The density function for the *Poisson* regression is:

$$f(y_i \mid x_i) = \frac{e^{-\mu_i} \mu_i^{y_i}}{y_i!}$$

where the mean parameter is a function of the regression x, and a parameter vector, β

$E(y_i \mid x_i) = \mu_i \exp(x_i^{'}\beta)$ and $y = 0,1,2\ldots$

In the *Poisson* model the variance is set equal to the mean such that

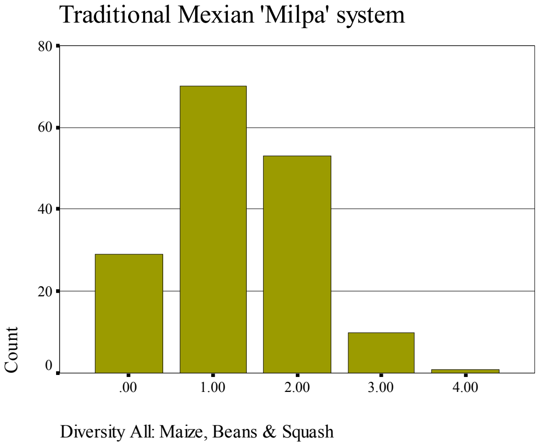
$V(y_i \mid x_i) = \mu_i(x_i, \beta) = \exp(x_i^{'}\beta)$

5.2.1 Dependent variable for *Poisson*-model

Given the interest to study biodiversity conservation on farm (*in-situ*) at the household level, the number of farmer varieties or local crops is used as a simple measure of richness, that is, a count of the number of crops that the household plants in the *Milpa*-system (van Dusen, 2000). The count of crops is what is used as the dependent variable in the regression model.

The structure of the dependent variable is also shown in the form of histogram in Figure 5.2. In this graphical representation, the dependent variable has the typical Poisson distribution. The variable has a large number of zeros and a mixture process may improve the model.

Figure 5.2: Histogram for dependent variable (for Poisson model)



Source: survey data

5.2.2 Explanatory variables for ***Poisson*-model**

The explanatory variables are divided into three groups: households' characteristics Ψ_{HH}, farm characteristics Ψ_{Farm} and government program characteristics $\Psi_{Gprogram}$. The summary statistics for each set of explanatory variables are presented in Tables 5.9, 5.10, and 5.11 respectively.

Table 5.9: Households characteristics for Oaxaca (for Poisson model)

Variable name	Variable description	Mean		Std. Dev		Min		Max	
		NC	C	NC	C	NC	C	NC	C
AGE	Age in years of the household head	48.38	50.74	12.66	14.09	30	19	80	80
EDUDUMY	1 if the farmer head has an education	0.83	0.72	0.38	0.45	0	0	1	1
ETHNICTY	1 if the farmer head is Non-Indigenous	0.90	0.43	0.31	0.50	0	0	1	1
HHSIZE	Number of people residing in household	5.24	5.84	2.34	2.58	2	2	12	16
SHAM1550	Share of male >15 & <50 years	14.34	13.23	15.43	14.34	0	0	50	50
HORSE	Number of horse owned by household	1.55	0.40	2.11	0.90	0	0	10	5
REMITTAN	1 if the farmer receives remittances	0.07	0.04	0.26	0.19	0	0	1	1
NUMUSES	Number of purposes for which maize is used	1.31	1.36	0.47	0.61	1	1	2	5

NC = Non-Conserver, n=29; C = Conserver, n=134

Farmer's age is an indicator of risk attitudes. Older farmers may be more conservative and risk-averse. They may also have better knowledge of local landraces and be more willing to plant them (Bellon et al., 2005). Age is included in order to assess whether older farmers are the ones conserving diversity because of traditional practices or tastes or preferences.

Education. The measure of education is years of schooling; in this case, education is a dummy variable where 1 indicates if the farmer has an education and 0 otherwise. The sign of this variable is expected to be negative if the farmer plants a traditional *Milpa*-system which is not knowledge demanding. The traditional system is transmitted from parents to children like inheritance.

Ethnicity. The variable coefficient's sign is expected to be negative, where indigenous farmers are more likely to attach stronger cultural values to maize consumption than non-indigenous farmers; hence they may prefer to plant landraces rather than modern varieties (Bellon et al., 2005).

Household size and the share of male members residing in the household between 15 and 50 years old is expected to be negative, as Bellon and Risopoulos (2001) finding suggests, maize landraces are "sturdy" and able to withstand delays in weeding without considerable drops in yield, require less fertilizer, and are more resistant to drought and pests. Consequently, landraces are less labor demanding than hybrids or OPVs.

Horses. The possession of horses by farmers is expected to be negative; if the farmer has horse is a measure of wealth, and maize landraces and minor crops are expected to be kept by poor farmers.

Remittances. In this particular model–conservation–remittances are expected to affect negatively maize diversity. The income transfer from abroad probably eliminates the cash constraint and the money could be invested in maize production or in other assets.

Number of Maize Uses. The number of purposes of growing maize and minor crops has direct impact on the number of varieties to be used on-farm as the survival of the household members will heavily depend on the crop. The farmers have reported four major purposes (food as dry-corn, fodder for animals, fuel in the cooking process, and "elotes" as green-corn on the cob) of growing maize in Oaxaca study area. In this particular case the coefficient's sign is expected to be positive, if the number of purposes increases, this contributes positively to enhance the number of maize landraces. As Wale-Zegeye (2004) argues: "farmers with a multiplicity of farm household concerns (purposes) have superior propensity to demand for more local varieties. This implies that a single variety does not satisfy multiple purposes to which farmers wish to place the variety.

Table 5.10: Farm characteristics for Oaxaca (for Poisson model)

Variable name	Variable description	Mean		Std. Dev		Min		Max	
		NC	C	NC	C	NC	C	NC	C
NUMPLOTS	Number of plots	1.17	1.12	0.47	0.41	1	1	3	3
AREAMAIZ	Area planted with maize (ha)	1.69	0.99	2.65	0.69	0.2	0.1	15	5.6
STICKSYS	1 if the farmer use stick or "*Coa*"	0.41	0.86	0.50	0.35	0	0	1	1
REDSOIL	1 if the plot has red soil	0.28	0.12	0.45	033	0	0	1	1
FLAT	1 if the plot is flat	0.31	0.24	0.47	0.43	0	0	1	1

NC = Non-Conserver, n=29; C = Conserver, n=134

Area under maize. The expected sign for the area planted with maize is expected to be negative, if the area with maize increase is likely that the number of landraces and minor crops decrease. Large farm size is strongly associated with welfare; consequently increase the probability of maize technology adoption.

Number of plots. This variable is expected to influence the likelihood to increase the number of landraces and minor crops. Brush (1995) points out the factors that promote in-situ conservation: the fragmentation of land holdings, marginal agricultural conditions associated with hilly lands and heterogeneous soils. In this way, the sign is expected to be positive.

Stick system. This variable is measure of capital intensity, if the farmer uses a stick or spade called “Coa” to plant maize and minor crops highlights that the production is intensity on human-capital. Doss (2003) argues that hand tools for land preparation may be a measure of wealth. The coefficient’s sign for stick-system is expected to be positive; if small-scale farmer is low in mechanical capital intensive, he is likely to conserve maize landraces.

Red soils. Red soils were ranked among the highest land quality in the focus group. The sign is expected to be negative, otherwise good soil quality contribute to technology adoption.

Flat area was also ranked among the highest land quality in the discussions group. The sign is expected to be negative, because flat area is preferred for modern maize varieties or cash crops.

Table 5.11: Government programs for Oaxaca (for Poisson model)

Variable name	Variable description	Mean		Std. Dev		Min		Max	
		NC	C	NC	C	NC	C	NC	C
SUBSIDY	Government subsidy: *PROCAMPO*	0.79	0.72	0.41	0.45	0	0	1	1
SEEDX	Government MV-Seed exchange program	0.41	0.22	0.50	0.42	0	0	1	1
EXTENS	If the farmer has access to extension program	0.14	0.10	0.35	0.30	0	0	1	1

NC = Non-Conserver, n=29; C = Conserver, n=134

The last group of variables correspond to access to government policy programs by farmers, and are expected to be negative, otherwise contribute to maize technology adoption.

5.3 Specification of Propensity score matching

This section discusses the *causal-effect* of maize technology adoption on poverty Propensity Score Matching (PSM) approach is employed. This method is appropriate because cross section data not provide adequate information on the household status before and after adoption of a technology (Hujer et al., 2004). If technology was randomly assigned to households, the *causal-effect* of technology adoption on household's livelihood could be evaluated as the difference in average wellbeing between adopters and non-adopters of the new technology (Mendola, 2007).

5.3.1 The evaluation problem

The impact of participation in program is

$\Delta = Y^1 - Y^0$

where Y^1 denotes the outcome conditional on participation and Y^0 denotes the outcome conditional on non-participation (Y can be continuous or dichotomous).

For each individual, only Y^1 or Y^0 is observed, so Δ is not observed for everyone. This missing data problem lies at the heart of the evaluation problem.

The most common evaluation parameter of interest is the average treatment effect on the treated (ATT): the ATT estimates the average impact of a program among those who participates in it.

$$ATT = E(\Delta \mid X, D=1) = (Y^1 - Y^0 \mid X, D=1) = E(Y^1 \mid X, D=1) - E(Y^0 \mid X, D=1) \quad (5.5)$$

where D = 1 denotes the group of individuals who applied and got accepted into the program for whom Y^1 is observed, D = 0 denotes persons who do not enter the program for whom Y^0 is observed. X denotes a vector of observed individual characteristics and used as conditioning variable.

In non-experimental (or observational) studies, no direct estimate of counterfactual mean $E(Y^0 \mid X, D=1)$ is available (Smith and Todd, 2005).

With observational data, the crucial problems that need to be tackled statistically are counterfactual mean missing, and 'self-selection' in farmer's adoption technology. This thesis tackles the statistical problems by employing a matching approach, in the analysis of maize technology adopters among similar non-adoption farmers.

This methodology assumes maize adoption technology to be similar to a "treatment". Where compare the average Per-Capita Expenditure (PCE) of maize technology adopter households and non-maize technology adopter households. The difference then would be attributed to the existence of adoption. The decision to be treated, although not random is assumed, ultimately depends upon observable variables. This assumption is less restrictive than assuming adoption depends on observables. While this may not be true, it could still be the case that adopting maize technology depends on observables (Esquivel and Huerta-Pineda, 2007).

The effect of technology adoption is computed as the average difference of the household's PCE between technology adopters and non-adopters households (where PCE is a continues variable). The household's wellbeing is captured bye a binary variable which indicates whether the household's expenditure lies below the food-poverty line (i.e., food-poor = 1) both effects take the form of an ATT effect (Rosenbaum and Rubin, 1983).

5.3.2 Propensity Score Matching (PSM)

One problem in matching studies is that the assignment of subjects to the treatment and control groups is not random and therefore the estimation of the average treatment effect is usually biased as a result of the existence of confounding factors. The matching between treated and control subjects thus become difficult when there is a *n*-dimensional vector of characteristics. This problem could be addressed by using the PSM method that summarizes the pre-treatment characteristics of each subject into a single index variable, and then used to match similar individuals (Rosenbaum and Rubin, 1983). Propensity score also reduces the bias if it compares outcomes of treated and control group, which are as similar as possible.

The PSM, which is the probability of assignment to treatment conditional on pre-treatment variables is given by:

$$p(X) = \Pr[D = 1 \mid X] = E[D \mid X]; \qquad p(X) = F(h(X_i)) \tag{5.6}$$

where:

$F(\cdot)$ can be normal or logistic cumulative distribution.

$D = 1$ if the subject was treated and 0 = Otherwise.

$X =$ a vector of pre-treatment characteristics.

To estimate ATT effect based on the propensity-score; Rosenbaum and Rubin (1983) established the following conditions:

Condition 1: Balancing hypothesis: $D \perp X \mid p(X)$

For observations with the same propensity score, the distribution of pre-treatment characteristics must be the same across control and treated groups. Conditional on the propensity score, each individual has the same probability of assignment to treatment, as in a randomized experiment.

Condition 2: Unconfoundedness given the PSM: $Y_1, Y_0 \perp D \mid X \Rightarrow Y_1, Y_0 \perp D \mid p(X)$

If assignment to treatment is unconfounded conditional on the variable pre-treatment, then assignment to treatment is unconfounded given the propensity-score. In other words, by employing the conditional independence assumption (CIA), it is possible that the average potential income (or expenditure) in the whole population of adopters can be measured by the average actual income (expenditure) of adopters, which solves the unobserved counterfactual.

Once the propensity score has been computed the ATT effect can be estimated as follows:

$$ATT = E(Y_i^1 - Y_i^0 \mid D = 1)$$

$$ATT = E[E(Y_i^1 - Y_i^0 \mid D_i = 1, p(X))]$$

$$ATT = E[E(Y_i^1 \mid D_i = 1, p(X)) - E(Y_i^0 \mid D_i = 0, p(X) \mid D_i = 1] \qquad (5.7)$$

where:

Y_i^1 is the potential outcome if the individual is treated.

Y_i^0 is the potential outcome if the individual is not-treated.

5.3.3 Matching methods

Calculating this effect is not immediately obvious since the propensity score is a continuous variable. To overcome this problem, four different matching methods have been proposed in the literature. Nearest Neighbor, Radius, Kernel and Stratification Matching (Becker and Ichino, 2002). As pointed of by Becker and Ichino (2002) Nearest Neighbor (NN) and Kernel Based (KB) methods are robust that the others.

Nearest Neighbor Matching (NNM)

This method consists of matching each treated individual with the control individual that has the closest propensity score. It is usually applied with replacement in the control units. The second step is to compute the difference of each pair of matched units, and finally the ATT is obtained as the average of all these differences. It should be noticed that each treated unit has a match, but this is not necessarily the best match since it only needs to be closest to be treated.

The ATT effect in the Nearest Neighbor matching is computed as:

$$\tau^{NN} = \frac{1}{N^T}\sum_{i\in T}\left[Y_i^T - \sum_{j\in C(i)} w_{ij}Y_j^C\right]$$

$$= \frac{1}{N^T}\left[\sum_{i\in T} Y_i^T - \sum_{i\in T}\sum_{j\in C(i)} w_{ij}Y_j^C\right]$$

$$= \frac{1}{N^T}\sum_{i\in T} Y_i^T - \frac{1}{N^T}\sum_{j\in C} w_j Y_j^C \tag{5.8}$$

where

$w_{ij} = \frac{1}{N_i^C}$ if $j \in C(i)$ and $w_{ij} = 0$ otherwise.

$w_j = \sum_i w_{ij}$, and

$C(i) = \min\left\| p_i - p_j \right\|$ for the nearest neighbor matching method.

N^C is the number of the control observations and

N^T is the number of the treated observations.

The NN actually identifies for each household the “closest pair” in the opposite technological status, and then goes on to compute the technological effect on the average difference of the household income (expenditure) between each pair of matched household.

Kernel Based Matching (KBM)

In this matching procedure, all treated subjects are matched with a weighted average of all controls using weights that are inversely proportional to the distance between the propensity score of treated and controls. The ATT is computed as follows:

$$\tau^K = \frac{1}{N^T}\sum_{i\in T}\left[Y_i^T - \frac{\sum_{j\in C} Y_j^C G\left(\frac{p_j - p_i}{h_n}\right)}{\sum_{k\in C} G\left(\frac{p_k - p_i}{h_n}\right)}\right] \tag{5.9}$$

where $G(\cdot)$ is a Kernel function and h_n is a bandwidth parameter.

The choice of the matching method involves a trade-off between matching quality and variance (Figure 5.3). First, one has to decide how many non-adopters farmers to match to a single adopter farmer. NNM matching uses only the participant and its closest neighbor. So it minimizes the bias but might also involve an efficiency loss, since a large number of close neighbors are disregarded. KB matching on the other hand, uses more non-adopters for each adopter thereby reducing the variance but possibly increasing bias. Finally, using the same non-adopter farmer more than once (NNM matching with replacement) can possibly improve the matching quality but could increase the variance.

Figure 5.3: Trade-offs in terms of bias and efficiency

Selection:	Bias	Variance
Nearest Neighbor Matching NNM:		
Multiple neighbors / Single neighbor	(+) / (-)	(-) / (+)
With caliper / Without caliper	(-) / (+)	(+) / (-)
Use of control individuals:		
With replacement / without replacement	(-) / (+)	(+) / (-)
Choosing method:		
Kernel Base-Matching / NN-Matching	(+) / (-)	(-) / (+)
Bandwidth choice with KBM:		
Small / Large	(-) / (+)	(+) / (-)

Increase: (+); Decrease: (-)

Source: adapted from Caliendo and Kopeining (2005).

In the case of NNM, all the treated units find a match. However, some of these matches are fairly poor because for some treated units, the nearest neighbor may have a very different propensity score and nevertheless NNM would contribute to the estimation of the treatment effect independently of these differences. KBM offer a solution to this problem, with this method, all treated units, are matched with a weighted average of all controls with weights that are inversely proportional to the distance between the propensity scores of treated and controls (Becker and Ichino, 2002).

5.3.4 Common support

A further requirement besides CIA, is the common support condition. It requires that all individuals in that subspace actually can participate in all states, where $D = 1$ given X:

$$0 < P(D = 1 | X) < 1$$

This condition actually improves the quality of the matches by excluding the tails of the distribution of p(X)[16].

5.3.5 Matching quality

Since analysis does not condition on all covariates but on the propensity-score, it has to be checked if the matching procedure is able to balance the distribution of the relevant variables in the control and treatment groups. The basic idea is to compare the situation before and after matching and check if there remain any differences after conditioning on the propensity score (Caliendo and Kopeinig, 2005). Sianesi (2004) suggest to re-estimate the propensity score on matched sample, only on adopters and matched non-adopters and compare the pseudo-R^2's before and after matching. The pseudo-R^2 indicates how well the regressors X explain the adoption probability. After matching there should be no systematic differences in the distribution of covariates between both groups and therefore, the pseudo-R^2 should be fairly low. The test should not be rejected before, and should be rejected after matching (Caliendo and Kopeinig, 2005).

5.4 Maize adoption and poverty relationship

This section presents the empirical specification of PSM method. It is worthwhile to illustrate graphically and statistically the differences between adopter and non-adopter farmers in the average per-capita monthly expenditure before showing the PSM results. A simple *t*-test is suggested to illustrate the significant differences in the average per-capita expenditure among maize adoption condition's farmers.

5.4.1 Determinants of poverty

Poverty is a fundamental component in this study and the first question is: who is poor. Three measures are employed to assess the poverty status. The index, suggested by

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[16] As argued by Heckman et al., (1997) non-parametric matching methods can only be meaningfully applied over regions of overlapping support.

Foster, Greer and Thorbecke [FGT] (1984), is used to capture these three poverty measures, specified as:

$$p(\alpha) = \frac{1}{N}\sum_{i=1}^{q}\left(\frac{z - c_i}{z}\right)^{\alpha} \tag{5.10}$$

Where N is the population size and c_i is the per-capita consumption (or income) of the *i-th* household, z is the food-poverty line, q is the number of poor individuals, and α is the weight attached to the severity of household poverty. (For more details on the use expenditures *vs*. income see Deaton, 1998).

The three poverty measures are:

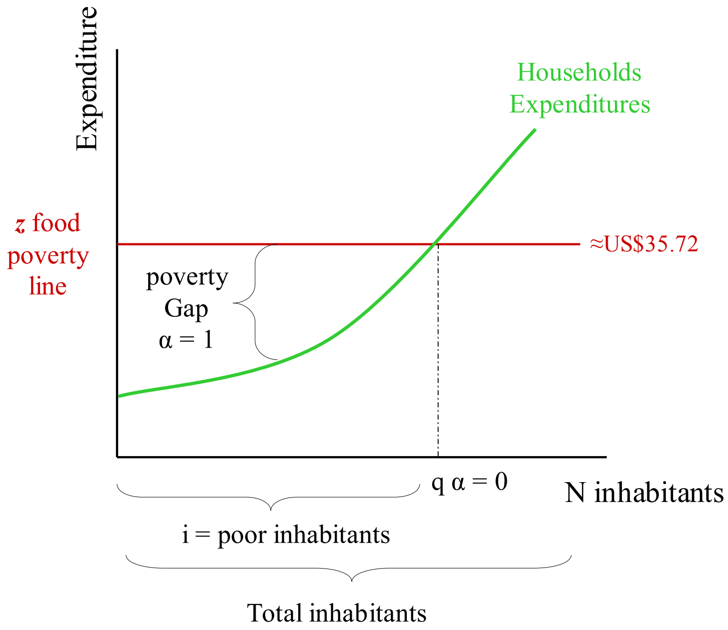
When α = 0 this corresponds to "headcount index" (share of population living in households with expenditures below the poverty line).

When α = 1 show the "poverty gap" (the mean distance below the poverty as a proportion of the poverty line).

When α = 2 represent the "severity of poverty". The index assigns more weight to individuals that are further away from the poverty line, so as to reflect inequality among the poor.

The Figure 5.4 shows the food-poverty line and the shape of household's expenditures.

Figure 5.4: Food poverty line



Source: adopted from Guevara et al., (2000)

5.4.2 Poverty analysis

Poverty is prevalent in both study areas, even in the more commercialized and developed Chiapas. Poverty rates were calculated with data on households consumption obtained from the survey. These data included both purchased and self-produced items to which local prices for similar goods and services were imputed. The food poverty line was constructed from Foster, Greer and Thorbecke (Foster et al., 1984). Based on this line the poor farmers were defined when expenditures are below the food poverty line, and non-food poor when the expenditures are above the line. The food poverty line is the value of food standard basket equivalent to MX$ 332.52 or approximately US$ 36 per-person per month[17].

The three alpha indices are presented in Table 5.12. The objective is to study the link between maize technology adoption and poverty alleviation (the econometric results are presented and discussed in section 6.3 below). Here is presented the relationship among poor farmers profile and adoption condition for both regions.

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[17] At the time of the survey October-December 2001 the rate change was roughly MX$ 9 = US$ 1.

Table 5.12: Poverty indicators results

	Oaxaca all		Chiapas all	
Headcount index	0.672		0.566	
Poverty gap	0.230		0.180	
Severity of poverty	0.109		0.080	
	Adoption	No-Adoption	Adoption	No-Adoption
Headcount index	0.595	0.708	0.543	0.648
Poverty gap	0.229	0.231	0.168	0.219
Severity of poverty	0.111	0.108	0.075	0.100
	Non-Indigenous	Indigenous		
Headcount index	0.589	0.750		
Poverty gap	0.195	0.263		
Severity of poverty	0.088	0.128		

* The value of Standard Food Basket per-capita month = MX$332.52 = US$35.71
Source: Field survey data, 2001

Per capita expenditure was calculated and adjusted to adult equivalents based on the weights used by Skoufias et al. (1999). Furthermore, household expenditure in Oaxaca was adjusted to make it equivalent to purchasing power in Chiapas because prices for similar goods were higher in Oaxaca than in Chiapas.

Most farming households in Oaxaca and Chiapas (62.7% and 56.6%, respectively) fall under the food poverty line. The headcount index, the poverty gap, and the severity of poverty index show that there are more poor people, a wider poverty gap, and more extreme poverty in Oaxaca than in Chiapas.

The difference between adopter and non-adopter farmers, the results of three index show that non-adopters households are poorer than adopter farmers in both regions. The poverty analysis was also calculated in Oaxaca, differentiating between ethnic groups of farmers (indigenous and non-indigenous), the results are as expected, indigenous farmers are poorer than non-indigenous.

Tables 5.13 and 5.14 show the results of *t*-test for overall maize (include maize hybrid, OPV's and creolized varieties) adoption in Chiapas. There is a statistically significant difference on the per capita expenditure average of MX$ 132 (approximately US$ 14) between adopter and non-adopter farmers.

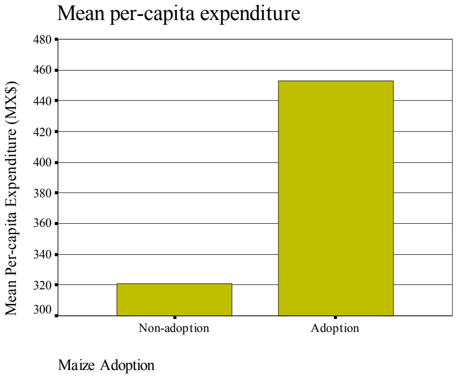
Table 5.13: Chiapas: per-capita expenditure (all MT)

Maize Adoption	N	Mean MX$	Std. Dev.	Std. E.
Adoption	130	452.77	302.19	26.50
Non-adoption	32	320.73	166.47	29.43

Table 5.14: *t*-Test for maize adoption (all MT) in Chiapas: per-capita expenditure

Levene's Test for Equality of Variances		t-test for Equality of Means		Sig. (2-tailed)	Mean Difference	Std. Error Difference
F	Sig.	T	df		MX$	
7.129	0.008	2.381	160.00	0.018	132.04	55.46

Figure 5.5: Chiapas: maize adoption (all MT)



Source: survey data

Figure 5.5 illustrates graphically the average differences, non-adopter farmers are considered poor because their average per-capita expenditure is under the food poverty line, and is equal to MX$ 320.73 (Table 5.13) or US$ 34.44, in other words, farmers who live on one dollar per day.

Table 5.15: Chiapas: per-capita expenditure (Hybrid)

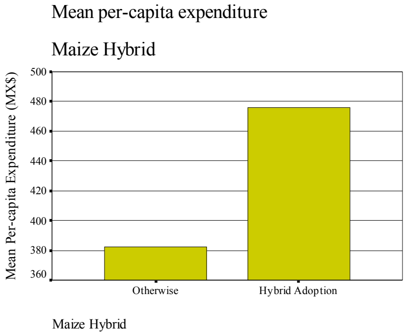
Maize Hybrid	N	Mean MX$	Std. Dev.	Std. E.
Hybrid Adoption	77	476.01	345.18	39.34
Otherwise	85	382.01	209.15	22.69

Table 5.16: *t*-Test for maize adoption (Hybrid) in Chiapas: per-capita expenditure

Levene's Test for Equality of Variances		t-test for Equality of Means		Sig. (2-tailed)	Mean Difference	Std. Error Difference
F	Sig.	T	df		MX$	
11.380	0.001	2.118	160.00	0.036	94.00	44.38

Table 5.16 shows the results for maize hybrid adoption in Chiapas, where the average difference of per-capita expenditure is positive and statistically significant. The difference is approximately MX$ 94 (US$ 10.9).

Figure 5.6: Chiapas: maize adoption (Hybrid)



Source: survey data

Figure 5.6 illustrates explicitly the differences among maize hybrid adopters and non-adopters.

The results for Oaxaca are presented in Tables from 5.17 to 5.20, as well as the graphs of differences on per-capita expenditure average.

Table 5.17: Oaxaca: per-capita expenditure (all MT)

Maize Adoption	N	Mean MX$	Std. Dev.	Std. E.
Adoption	52	493.84	431.87	59.89
Non-adoption	111	383.47	390.90	37.10

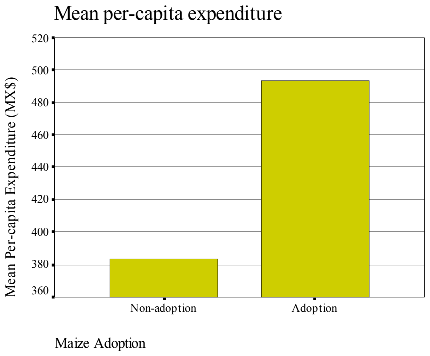
According to Table 5.18 there is no statistically significant difference in the average of per capita expenditure for overall maize adoption. The difference is MX$ 110.37 (US$ 11.85). According to *t*-test results there is significance only at slightly above 10% level of significance. But the purpose here is to visualize the average difference among technology adopters and non-adopters farmers.

Table 5.18: *t*-Test for maize adoption (all MT) in Oaxaca: per-capita expenditure

Levene's Test for Equality of Variances		t-test for Equality of Means		Sig. (2-tailed)	Mean Difference	Std. Error Difference
F	Sig.	T	Df		MX$	
4.574	0.034	1.624	161.00	0.106	110.371	67.945

Figure 5.7 below presents graphically the average difference among small-scale farmers, regarding their technology condition.

Figure 5.7: Oaxaca: Maize Adoption (all MT)



Source: survey data

Table 5.19: Oaxaca: per-capita expenditure (all MT)

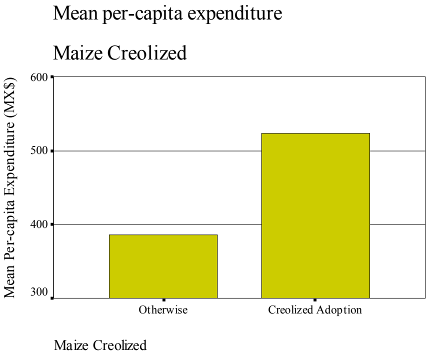
Maize Creolized	N	Mean MX$	Std. Dev.	Std. E.
Creolized Adoption	39	522.73	458.05	73.35
Otherwise	124	385.95	384.91	34.57

Finally Table 5.20 shows *t*-test result for creolized maize adoption, where there is a positive and statistically significant difference between farmers who adopt creolized maize varieties and who not adopt on average of MX$ 136.77 (US$ 14.69).

Table 5.20: *t*-Test for maize adoption (Creolized) in Oaxaca: per-capita expenditure

Levene's Test for Equality of Variances		t-test for Equality of Means		Sig. (2-tailed)	Mean Difference	Std. Error Difference
F	Sig.	T	df		MX$	
4.546	0.035	1.847	161.00	0.067	136.775	74.056

Figure 5.8. Oaxaca: maize adoption (Creolized)



Source: survey data

Lastly, figure 5.8 shows graphically the difference among maize creolized adopters and non-adopters farmers.

The first problem arises because the analysis wants to know the difference between the farmers' outcome (or PCE) with and without adoption. Clearly, it cannot observe both outcomes for the same individual at the same time. Taking the mean outcome of non-adopters as an approximation is not advisable, since adopters and non-adopters usually differ even in the absence of treatment.

The matching approach is the possible solution to the selection problem. Its basic idea is to find in a large group of non-adopters those individuals who are similar to the adopters in all relevant pre-treatment characteristics *X*. That being done, differences in outcomes of this well selected and thus adequate control group and of participants can be attributed to the maize adoption.

Chapter 6

Results from the econometric model

The chapter's objective is to show the econometric results for maize technology adoption; maize, beans and squash *in-situ* conservation, as well as the *causal–effect* of improved germplasm adoption on poverty alleviation. Consequently, the chapter has three sections. 6.1 presents the *Probit*-model results, factor by factor, of maize technology adoption. Section 6.2 provides evidence of factors that contribute to maize landraces in-situ conservation on small-scale farmers' fields done by *Poisson*-model. Lastly section 6.3 shows the *causal-effect* of improved germplasm adoption on the average per-capita expenditure between farmers who adopt and who do not adopt maize germplasm, done by propensity score matching method.

6.1 Maize adoption

The *Probit*-model was estimated using the LIMDEP© statistical package. The results of *Probit*-model for maize technology adoption are reported in tables 6.1 and 6.2 for Chiapas and Oaxaca respectively. To measure the performance of the model, the McFadden R^2 and the log-likelihood are reported. The R^2 is calculated as $R^2 = 1 - L_\Omega / L_\omega$, where L_Ω is the unrestricted maximum log-likelihood and L_w is the restricted maximum log-likelihood with all slope coefficients set equal to zero (Greene, 2003). The percentage of correct predictions is calculated as the total number of predictions as a percentage of the number of observations. The model correctly predicts the maize adoption for 84 and 74 per cent of the sample for Chiapas and Oaxaca respectively.

6.1.1 Maize adoption in Chiapas

The results of the econometric analysis are shown in Table 6.1. Coefficient's column reports parameter estimates of a *Probit*-model on the probability of maize technology adoption. The estimation model is statistically significant at the 1 percent level or better, as measured by the likelihood ratio test. The results in the coefficients column suggests that the probability of adoption is influenced significantly by a number of economic characteristics of the farm, where the socio-economic attributes of the household (e.g., age of the farmer head, number of family members, farm size, and soil quality) strongly influence the likelihood of adopting a modern maize variety.

According to Table 6.1, an increase in age decreases the probability of maize technology adoption; the parameter is negative and significant. The results are in agreement with the adoption theory. Furthermore, education (as dummy variable) has the expected sign in its coefficient, but is not significant. Both, age and education are in agreement with human capital theory.

Table 6.1: Parameters for *Probit*-model for farmer's maize adoption in Chiapas

Variable	**Coefficient**	***t*-Ratio**	**Sig.**
Constant	2.611	2.867	***
Households Characteristics			
AGE	-0.020	-1.910	*
EDUDUMMY	0.516	1.543	
HHSIZE	-0.179	-2.460	**
SHAM1550	0.028	2.269	**
STAPLEC	-0.297	-2.294	**
HORSE	0.671	2.515	**
REMITTAN	0.444	0.703	
DISTANCE	-0.018	-1.944	*
Farm Characteristics			
LANDOWNER	1.142	1.752	*
NUMPLOTS	-0.269	-1.336	
AREAMAIZ	0.122	1.733	*
ARED	0.096	0.823	
SLOPE	-0.663	-2.221	**
Government Programs			
SUBSIDY	-1.077	-1.707	*
SEEDX	0.392	1.070	
ACCESEXT	0.233	0.848	

Chi-square: 50.75055; *p*-value: 0.000017

R^2: McFadden = 0.31519

Predicted: 83.95%; N = 162

The household labor availability–manpower–as measure of household size and share of male members residing in the household have the expected coefficient signs and both are significant. Thus indicates that if the share of male members between 15 and 50 years old increases, the likelihood of modern maize varieties adoption increases. The household size coefficient has the expected sign; indicating when the number of family members increase, this decreases the likelihood of maize adoption, because the share of male family members controls the pool of manpower availability, i.e., the household size controls for female, children and old family members residing in the household.

Staple crops variable (include: beans, squash, chili, and fruit trees) has the anticipated sign in its coefficient and is significant. The result suggests that modern varieties generally are planted in high population density areas i.e., number of maize plants by area. If the farmer intercrops minor varieties such as *Milpa* system this reduces the likelihood to adopt high yielding varieties.

Horses: if the household has a horse this increases the probability of maize adoption, i.e., the variable has the expected sign, and is statistically significant as well. In Mexico, particularly in the region the horse is a capital asset indicating wealth. The horse, unlike in other countries, is employed as traction potential and transportation by the farmers. The variable results, suggests that a horse is a capital asset and contributes significantly to maize technology adoption.

Remittance, the variable’s coefficient has the expected sign, but is not significant, Suggesting if the household receives remittances from abroad it could increase the probability of maize technology adoption, i.e., the sign suggests that remittances reduce the cash constraint. Remittances are not significant probably due the majority of the households do not have the experience of emigration as other regions in Mexico, where most of the households have at least one family member in US, like Michoacán, Zacatecas or any northern Mexican state, close to the US border.

The variable distance has the expected sign and is statistically significant, suggesting that if distance increases, between the farm household and principal market, this reduces the likelihood of maize technology adoption. Distance is a proxy variable of transactions costs.

Regarding farm characteristics, land ownership has the expected sign in its coefficient and is statistically significant, i.e., if the farmer is the owner of the land, this increases the probability of maize technology adoption as a measure of welfare. The result is in agreement with Abdulai and Binder (2006) findings in Nicaragua.

The number of plots has the expected sign in its coefficient, but is not significant. If the number of plots increases, this reduces the probability of maize technology adoption, as a proxy of land fragmentation, i.e., if fragmentation increases, the farmer has to invest more time attending to different plots located in different places. Usually, hybrid or OPV germplasm are time and labor demanding, consequently, if the number of plots increases, the farmer has to invest more time and labor. In the model of socio-economic constraints, fragmentation reduces the maize technology adoption likelihood. These results are in agreement with Bellon and Risopoulos (2001) findings.

Area planted with maize has the expected sign in its coefficient and is statistically significant, suggesting that if the area increases, this increases the probability of maize technology adoption. Area planted with maize is a proxy for farm size. The result is in agreement with agricultural technology adoption literature, where large farm size is an indicator of welfare.

Area with red soil has the expected sign in their coefficient, but is not statistically significant. The color of the soil plays an important role and is correlated with fertility. Red soil characteristic was ranked among the best quality in the focus group carried out in the villages. If the area red increases the probability of modern maize varieties adoption increases as well.

The slope area variable has the expected sign in its coefficient and is statistically significant. If the slope of the area increases it reduces the likelihood of modern germplasm adoption. The variable indicates soil quality, generally slopy soils are ranked as poor quality, because this type of soils has less moisture retention, the maize plant density is less than flat areas. Farmers prefer to invest in good quality soils, flat, deep, water drainage, and moisture retention, than in poor soils. The result is in agreement with agricultural adoption literature.

Lastly, the set of government program variables characteristics are presented. The *PROCAMPO* subsidy program has an unexpected sign and is statistically significant.

But this finding supports the local opinion about the government cash transfer, where the majority of the small-scale farmers said that the subsidy came to late, after the planting season, i.e., after the fundamental time to acquire inputs (seed, fertilizers, and herbicides, labor and machinery payments). Regarding to *Kilo por Kilo* program has the expected sign in its coefficient, but is not statistically significant. This is probably due to the fact that the program was not strong and did not target the technological change objective. Perhaps, the improved germplasm transferred by the government agency was not suitable for the region or environment. Finally, access to extension programs variable has the expected sign, but is not significant, probably due government program that is not effective, and did not provide enough information to the farmers.

6.1.2 Maize adoption in Oaxaca

In the case of Oaxaca few variables are statistically significant, and most of the non-significant variables have the expected coefficient sign, indicating that few variables explain maize adoption as expected. This is probably due to the fact that few farmers adopt maize technology, Tables 4.1 and 5.1 in sections 4.2 and 5.1 above respectively showed very clear the socioeconomic differences between Chiapas and Oaxaca regions. This socio-economic difference supports the argument of to analyze separately both regions, i.e., one *Probit* model for each region.

The Oaxaca's estimation model is statistically significant at the 1 percent level or better as measured by the likelihood ratio test. A general overview of the results shows that a set of key variables strongly explains the maize adoption pattern in Oaxaca. The socio-economic attributes of the household (e.g., non-indigenous farmers, manpower availability, remittances, and distance) contribute to the likelihood of adopting a modern germplasm.

According to Table 6.2, the variable, farmer's age, has an unexpected sign in its coefficient and is not significant. Education's coefficient has the expected sign, but is not significant as well. This is probably because few farmers plant modern varieties, According to table 4.1 above only 6.6 and 1.1 hectares were planted with maize hybrid and OPV varieties respectively. Or in other words, only six of the 163 farm households adopted the improved germplasm (Table 5.1 above).

Ethnicity’s coefficient is positive and significant, suggesting that to be a non-indigenous farmer increases the probability of maize technology adoption. Mostly, non-indigenous inhabitants speak Spanish; with this ability undoubtedly the farmer can understand most of the information available (extension programs and media information), regarding agricultural technology. Unfortunately, a few programs exist for indigenous inhabitants, regarding maize technology information extension there is no evidence of availability.

Household size and share of male members between 15 and 50 years old have the expected coefficient’s sign, but household size is not significant. The share of male members increases the probability of maize technology adoption. The result is in agreement with agricultural technology adoption literature, where it is hypothesized that modern maize seed varieties are labor and time demanding, because these seed usually is planted as technology package (e.g., fertilizer, pesticides and herbicides).

Staple crops has the expected sign, but is not significant. The variable’s sign suggest that if the number of minor crops (e.g., beans, squash, and chili) increases, this reduces the likelihood of maize technology adoption. Like in Chiapas (previous section above) when modern maize seeds are planted in high population density (number of maize plants by area) and minor crops generally are intercropped with maize, this reduces the probability of adopting new technology. Obviously, if the farmers are expecting high yields they may cultivate as many plants as possible.

Horses: Like in the previous analysis, horses play a key role in the farm household as traction potential, harvest transportation, and vehicle for the farmers. The coefficient for horse has the expected sign and is statistically significant suggesting that horse is a capital asset and it represents wealth.

Remittances have the expected sign and are statistically significant; proving the hypothesis that emigration–particularly remittances–has an effect on rural households. The recurrent economic crises during the last decades have prevented the rural population remaining in their places of origin and stimulated the expulsion of manpower to the industrial-sector. This has also been a detonator for emigration abroad. The zones that traditionally expelled manpower are located in the center and north of the country, *Zacatecas*, *Durango*, *Aguascalientes*, and *Michoacán*; however, over the last few years other Mexican states have been added to emigration including Oaxaca and Chiapas (Brush and Chauvet, 2004; Esquivel and Huerta-Pineda, 2007). The remittances sent during 2002, amounted US$ 9,815 million and in 2006 amounted to US$ 23,452 million (Banxico, 2007).

The rural emigration and its impacts is not necessarily the total abandonment of rural work, since the monetary remittances the migrants send to their families, is invested in maize cultivation in some regions. Remittances contribute to increase the likelihood of maize technology adoption on small-scale farmers. Brush and Chauvet (2004: 17) point out that remittances send by migrants to their families are invested in maize cultivation; as well maintain rural agricultural production and keep life ongoing. Remittances also reduce the cash constraints among small-scale farmers in agreement with adoption-economic constraint paradigm.

Distance has the expected sign and is statistically significant. Its result implies that if the distance increases, this reduces the probability of maize technology adoption by small-scale farmers. Distance is a proxy of transactions costs; households far away from the principal markets have higher transactions costs than their counterparts located close to the markets.

With regard to the set of farm characteristics, land ownership, number of plots, area planted with maize, red soils have the expected coefficients sign but are not significant. Only slope areas have the unexpected sign, and is not statistically significant, its sign probably is due to the fact that most of the land in Oaxaca is on hills or mountains. Slope areas probably are allocated most of the maize production, and in flat areas the cash-crops (e.g., sesame, cacao, peanut, tomatoes, vegetables, and hibiscus).

Good soil quality variable has the expected sign, and is statistically significant. If the farmer has good soil quality this increases the likelihood of maize technology adoption. The variable result is in agreement with agricultural technology adoption literature, where better soil quality increases the probability of agricultural technology adoption.

Table 6.2: Parameters for *Probit*-model for farmer's maize adoption in Oaxaca

Variable	Coefficient	*t*-Ratio	Sig.
Constant	-1.988	-2.043	**
Households Characteristics			
AGE	0.002	0.193	
EDUDUMMY	0.153	0.504	
ETHNICTY	0.725	2.765	***
HHSIZE	-0.007	-0.132	
SHAM1550	0.018	2.013	**
STAPLEC	-0.024	-0.180	
HORSE	0.247	2.003	**
REMITTAN	1.193	2.157	**
DISTANCE	-0.011	-1.645	*
Farm Characteristics			
LANDOWNER	0.106	0.313	
NUMPLOTS	-0.047	-0.149	
AREAMAIZ	0.118	1.137	
REDSOIL	0.500	1.483	
SLOPE	0.319	1.072	
GOOD	0.571	2.241	**
Government Programs			
SUBSIDY	0.184	0.627	
SEEDX	-0.412	-1.265	
ACCEXTEN	0.093	0.317	

Chi-square: 42.3188; p-value: 0.00099

R^2: McFadden = 0.20733

Predicted: 73.0%; N = 163

The last set of variables corresponds to government programs. All the variables are not significant. The coefficient of *Kilo por Kilo* variable has unexpected sign. Probably due to the fact that the modern maize seed delivered by government agencies was not specifically for this particular environment, or failed to arrive on time. During the interview one farmer report that: "*I preferred to wash and cook the maize hybrid seed, because I could not plant the maize on time, the agency brought the seed too late, and we have a scarcity of maize grain for food.*"

The PROCAPO variable and access to extension programs are not significant, probably because the programs are still weak or do not have enough coverage among farmers, i.e., the programs do not target maize production technological change.

6.2 Biodiversity conservation

The *Poisson*-model was estimated using the LIMDEP© statistical package. The parameters of *Poisson*-model for the total number of maize landraces, beans and squash are reported in Table 6.3 for Oaxaca. The model was tested over-dispersion in STATA© and is not over-dispersed, that is Poisson model is well suited for this analysis. These results show that the household decision to plant a number of different crops and varieties of each crop is affected significantly by a number of socio-economic characteristics, where the socio-economic attributes of the household (e.g., age, ethnicity, number of purposes for which maize is used, number of plots, poor soil quality, and type plowing system–manual–) are the factors that significantly motivating farmers to manage a portfolio of local maize varieties, beans and squash.

The first set of characteristics presented in Table 6.3 and are those that are related to the household. The coefficient for age of the household head is positive and statistically significant, indicating that the older farmers are planting a greater number of varieties. This result is in agreement with van Dusen (2000) findings in *Sierra Norte de Puebla* (Mexico) and Wale-Zegeye (2004) in Ethiopia. As van Dusen (2000: 109) argues "the fact that it is an older generation who are conserving a greater amount of diversity presents problems for *in-situ* conservation if crop genetic resources are lost over time as the older generation ages and leaves farming."

Education was predicted to have a negative effect on demand for maize landraces, beans and squash count diversity. However, the variable has unexpected sign, but is not significant, reflecting the low level of education, i.e., in traditional systems, like *Milpa*, individual farmers transmit their knowledge from one generation to another the information required to select maize seed, as well as land preparation, and all the cultural activities required. Farmers also engage in exchanges with other neighboring farmers and communities interchanging knowledge (Perales et al., 2005).

Ethnicity, a measure of indigenous farmers, has the expected coefficient sign and is highly statistically significant. Indigenous farmers are more likely to attach stronger cultural values to maize consumption than non-indigenous farmers; hence, they may prefer to plant maize landraces rather than improved varieties. Maize genetic diversity is also related to the presence of different indigenous groups for which maize cultivation is not only a means to ensure physical subsistence, but also part of a deeper social and cultural process of co-evolution (Nadal, 2000). The strong interaction between culture and maize landraces is reflected by the ethnicity's coefficient and is highly significant. Brush and Chauvet (2004) point out "Abundant ethnographic evidence from rural Mexico testifies to the fact that maize plays a profound and complex role far exceeding that of a simple commodity. Maize *tortillas* are offered as sacraments; kernels are use in ritual divination; maize is accorded respect as a sapient being. So, growing a maize crop is evidence that a farmer is committed to the rural community, its connection to the past, and its values. The binding together of maize and rural community is evident in indigenous art and archaeology since before the European arrival in the New World."

Remittances variable. In recent studies advise that many maize producers are being forced to migrate to urban areas or other countries, principally USA (Nadal, 2000; Dyer and Yunez-Naude, 2003; Brush and Chauvet, 2004). The findings have revealed that the propensity to migrate is stronger in areas where poor small-scale farmers live (Nadal, 2000; Esquivel and Huerta-Pineda, 2007). Consequently, women, children and the elderly maintain the subsistence agriculture ongoing. Remittances play a key role on rural household livelihoods, but the sign in its coefficient's suggest that the money could be invested on agricultural inputs, like modern varieties, i.e., if the increases in remittances reduce the number of staple crops. The remittances' coefficient is not significant, the interpretation could be that the amount of the remittances is not significant, but it could be an indication of the tendency, and the threat of *in-situ* conservation of crop genetic resources on farmers' fields. Brush and Chauvet (2004: 17) point out that "the migratory flow is a substantial variable that must be taken into account [analyze] because its impact is not necessarily the total abandonment or rural works, since the monetary remittances the migrants send to their families, is invested in maize cultivation in some regions." Part of these resources, remittances, support maize production, it is a fact that there is scarcity of labor in the country and those varieties of maize that need more work may be lost. Maize landrace's seed need to be selected carefully by small-scale farmers' knowledge, and the elderly farmers are who poses the knowledge and wisdom to select and maintain local varieties. If male young farmers left the rural areas, and elderly farmers leaves farming, women and children may be not keep enough knowledge and wisdom about maize production with traditional seeds.

Probably, in many places the cheap and easy way is to buy modern varieties–in bag–and maintain the maize production ongoing, obviously if the remittances are significant as shown in the previous section 6.1.2.

Table 6.3: Parameters for Poisson model for farmer's maize, beans and squash conservation in Oaxaca

Variable	Coefficient	*t*-Ratio	Sig.
Constant	-0.725	-2.031	**
Households Characteristics			
AGE	0.007	1.783	*
EDUDUMMY	0.026	0.243	
ETHNICTY	-0.375	-3.543	***
HHSIZE	0.021	0.972	
SHAM1550	-0.003	-0.688	
HORSE	-0.118	-1.773	*
REMITTAN	-0.276	-1.221	
NUMUSES	0.282	3.004	***
Farm Characteristics			
NUMPLOTS	0.205	1.963	**
AREAMAIZ	-0.107	-1.726	*
STICKSYS	0.348	1.938	*
REDSOIL	-0.256	-1.751	*
FLAT	-0.160	-1.318	
Government programs			
SUBSIDY	-0.003	-0.027	
SEEDX	0.252	2.038	**
EXTENS	-0.145	-0.936	

Chi-square: 75.46686; p-value: 0.0000
N = 163

The number of uses variable has the expected sign and is highly significant. The results are in agreement with Wale-Zegeye (2004). Farmers with a variety of maize purposes or uses have superior propensity to increase the demand for local varieties. This implies that a single variety does not satisfy multiple purposes to which farmers wish to place the variety (e.g. food as dry-corn, fodder for animals, fuel in the cooking process, and "elotes" as green-corn on the cob). Farm households who fail to satisfy their subsistent needs from expected non-variety income and wealth have higher demand for multiple varieties of maize. They are trying to survive from the varieties that tolerate the unexpected stress condition by planting as many varieties as they can.

This result suggest that poor farmers depend on *Milpa* output, corroborating the hypothesis, the poverty obligates rural households inhabitants to plant subsistence crops. As Morris (1998) argues: "[…] once consumer incomes rise above a certain threshold level, direct human consumption of maize declines with additional growth in income. Above the threshold income level, consumers respond to additional increases in purchasing power by consuming less maize and greater quantities of higher-priced luxury foods, especially meat and dairy products, fruits, and vegetables."

Regarding the farm set of variables. In most applied work on crop diversity, fragmentation index (the ratio of the number of household plots to the total area of land operated) is used. However, it could be misleading because according to this index, a farm that has 2 plots with a size of 1 hectare each is equally fragmented (heterogeneous) with a single plot farm of half hectare. But heterogeneity is perhaps twice in the first than in the second (Wale-Zegeye, 2004). For this reason, the number of plots and area planted with maize (farm size) are used independently. Farmers who have reported more number of plots have reported more number of landraces i.e. an increase in number of plots increases the expected the number of landraces, beans and squash. Brush (1995) points out that the fragmentation of land holdings, marginal agricultural conditions associated with hill lands and heterogeneous soils promote the *in-situ* conservation of landraces. Bellon and Risopoulos (2001) findings show that most of the factors that generate a demand for maize diversity are: farmers with several soil types, fragmented landholdings, farmers pursing subsistence and commercial objectives simultaneously and attending diverse constraints.

If the area planted with maize increase, the likelihood of *in-situ* conservation of maize landraces and minor crops decreases. Large land holding increase the probability of maize technology adoption, as shown in section 6.1.2.

Stick system variable has the expected sign and is statistically significant. Firstly, stick or "Coa" is measure of human-capital intensity. According to Doss (2003) hand tools for land preparation could be a measure of wealth. The result on this variable suggests that farmers who have reported use of stick system have reported more number of local varieties i.e., an increase in hand-tools increases the probability to conserve traditional crops.

Red soils variable has the expected sign and is statistically significant. Red soils were ranked among the better soil quality in the focus groups carried out in Oaxaca. The variable's coefficient suggests that if the farmer has better soil quality, reduces the probability to conserve traditional crops. The result is in agreement with Brush (1995) and Bellon and Taylor (1993) who argues that traditional crops are allocated in marginal agricultural conditions and heterogeneous soils.

Flat area variable has the expected sign but is not significant. The sign suggests that if the flat area increases, this reduces the likelihood of maize landraces conservation and minor crops. Normally, flat area is preferred for modern maize varieties or cash crops.

The last set of variables corresponds to government program characteristics. The variable subsidy or PROCAMPO and extension, have the expected sign, but are not significant.

Seed exchange or *Kilo por kilo* program's coefficient is positive and significant, as Berthaud and Gepts (2004) and Perales et al. (2003b) argue that small-scale farmers are willing to modify introduced maize cultivars through recurrent hybridization with local genetic materials (process of creolization, Bellon et al. (2003)) to improve their local performance and consumer acceptability. The farmers do not consider this process as "contamination". However, if the introduction of modern varieties becomes a permanent and pervasive process, a threshold could be reached above which gene swamping from those cultivars would reduce or eliminate the genetic diversity of local landraces. Furthermore, as Berthaud and Gepts (2004) point out, the evolution of landraces, which is based on hybridization, recombination, and selection, may follow paths unsuspected for modern varieties. Seed-recycling and seed-flows management by small-scale farmers explain hybridization or creolization phenomenon.

Kilo por Kilo program, could also explain the high frequency of maize creolized in Oaxaca, such as Table 5.1 (upper) shown where roughly 20% of the households plant maize creolized.

The process of creolization has been well-studied and discussed in Bellon et al. (2003): "Most people consider recycled or "*acriollado*" seeds to be *criollos* in a few years. …

Key to classification as a *criollo* seed is that the seed has been "*acclimatized*" to local soils, i.e., seen as adapted to these soils. According to one farmer in Oaxaca: "*at first it was like a hybrid and now, later, it is criollo… It likes the soil. It acclimated.*" When asked whether this process was what makes a variety '*criollo,*' another farmer said "*yes, that is exactly what makes it criollo. After some seasons it adapts and will produce any place. Because they planted it once and now it knows the land and since the land is good [it produce].*" Farmers cultivate side by side various types of maize with various grades of creolization. The authors did not observe a direct replacement of landraces by the introduced modern varieties. What they observed was a genetic inter-gradation between modern varieties and local landraces, considered to have been in the area for a long time.

Maize choice in Mexico has favored the maintenance of traditional maize populations. However, it must be stressed that these populations are open systems in the sense that non-local material, including germplasm from improved and modern maize, is often acquired, evaluated, and incorporated into farmers' maize populations (Bellon and Risopoulos, 2001; Perales et al., 2003b; Brush and Chauvet, 2004).

Lastly, landraces are not static and perfectly distinct resources, but are continuously being exchanged, mixed, re-selected and re-adapted by farmers, through their social network (Perales et al., 2003b).

6.3 Causal effect of maize adoption on poverty alleviation

The relationship between technology adoption and rural poverty is theoretically complex, as there are empirical handicaps regarding the impact evaluation problem. Conditional on cross-sectional data availability, the analysis estimates the welfare effect of an improved maize variety adoption (e.g., maize hybrid, OPV, and creolized) on resource–poor rural households maize producing in Mexico. In particular, the analysis focuses on the underlying *causal-effect* of direct technology adoption on wellbeing.

Present analysis is based on propensity score matching method to measure the full size of the direct impact. Assuming that the method matches similar household, with different adoption status, that gained the same level of indirect effects. Although the analysis is unable to break down the separate effect of each channel on wellbeing, it is possible that the analysis of overall direct (in that deriving from adoption) impact of technology adoption in terms of *causal-effect* may have important predictive value of interest for this thesis and policy as well.

However, the question is: does technology have a positive direct effect on farm household's wellbeing? In a counterfactual framework: picking a household randomly, and going back in history, and changing the household technology availability. How would this alter its current wellbeing? (Kerr and Kolavalli, 1999; Evenson and Rosegrant, 2003; Mendola, 2007).

Besides technology, specific household characteristics have a role in determining the status of wellbeing of the household members, as much literature on household's welfare has pointed out this fact. Among household characteristics, the main determinants of rural income (and lack of it) are demographic characteristics along with land, human, and institutional assets (Mendola, 2007).

In this study the level of Per-Capita Expenditure is used as an indicator of household wellbeing. This includ data on both purchased and home-produced items, for which local prices of similar goods and services were imputed. Per capita expenditure was calculated and adjusted to adult equivalents, based on the weights used by Skoufias et al. (1999). Furthermore, household expenditure in Oaxaca was adjusted to make it equivalent to purchasing power in Chiapas because prices for similar goods were higher in Oaxaca than Chiapas (more in: Bellon et al., 2003).

6.3.1 Matching estimation procedure: implementation

For estimation the analysis considers the conditional independence assumption (CIA), requires that all variables (vector of characteristics *X*) that jointly influence the participation decision (dichotomy variable *D*) and the outcome variables PCE and poverty status (outcome *Y*) should fulfilled CIA. The used dataset contained three different categories of variables. First, socio-demographic variables like age, education share of family members living in the household between 15 and 50 years old, etc. Second, information regarding plot characteristics, e.g. farm size etc. Third, the dataset also include access to the labor and market, etc. So, based on this information the analysis assumes that CIA holds.

Propensity score implementation

The analysis estimates binary Logits for every treatment group or improved maize varieties adoption against the non-adopters group. The Logit models are estimated separately for all improved maize varieties and then for specific maize variety (i.e. hybrid or creolized), leaving it with four Logit estimations. The results of two different Logit models are reported in Tables 6.4 and 6.5 for Chiapas and Oaxaca, respectively. Table 6.4 shows the covariates: age (linear and squared), education level (linear and squared), number of male and female members between 15 and 50 years old. The variable household education average corresponds to education level for all the members residing in the household. The area (in hectares) planted with maize, the number of cash crops, and a dummy if the household received remittances from abroad, and the distance between the household and the principal market (in kilometers). Most variables have the expected signs: households that have young and educated members are more likely to adopt modern germplasm than other type of households.

Table 6.4: Propensity Score for maize adoption in Chiapas (Logit)

	All Improved Maize			Maize Hybrid		
	Coef.	Std. Err.	z	Coef.	Std. Err.	z
AGE	0.167	0.091	1.84	0.070	0.081	0.87
AGE2	-0.002	0.001	-2.18	-0.001	0.001	-0.87
EDU	0.357	0.211	1.69	0.083	0.168	0.50
EDU2	-0.042	0.020	-2.14	-0.007	0.016	-0.44
MALE1550	-0.101	0.261	-0.39	-0.214	0.223	-0.96
FEMA1550	-0.984	0.289	-3.40	-0.409	0.223	-1.83
HHEDUAVE	0.342	0.136	2.52	0.075	0.091	0.83
AREAMAIZ	0.108	0.080	1.34	0.231	0.067	3.47
CASHCROP	0.330	0.332	0.99	-0.459	0.366	-1.25
REMITTAN	-0.586	0.523	-1.12	-0.494	0.438	-1.13
DISTANCE	-0.006	0.012	-0.53	-0.008	0.010	-0.85
CONS	-2.044	2.350	-0.87	-2.131	1.976	-1.08

Table 6.5 presents the covariates: age, education level, the interaction term age by education, household size and the share of female members between 15 and 54 years old residing in the household. Five variables of farm characteristics are included: the land ownership, the number of plots, the farm size (area planted with maize), and two dummy variables are used for good soil quality and slope. Lastly, the distance between the household and the principal market is included. Most variables have the expected signs: households that have young farmers, less female members, education, and less distance between the household and the main market are more likely to adopt modern maize varieties.

Table 6.5: Propensity Score for maize adoption in Oaxaca (Logit)

	All Maize Types			Creolized Maize		
	Coef.	Std. Err.	z	Coef.	Std. Err.	z
AGE	-0.004	0.022	-0.20	-0.003	0.024	-0.14
EDU	-0.229	0.314	-0.73	-0.216	0.342	-0.63
AGEEDU	0.005	0.007	0.74	0.005	0.007	0.63
HHSIZE	-0.021	0.078	-0.28	0.010	0.083	0.12
SHAF1554	-3.873	1.445	-2.68	-2.313	1.510	-1.53
LANDHOLD	0.317	0.509	0.62	0.320	0.555	0.58
DISTANCE	-0.024	0.009	-2.52	-0.024	0.010	-2.35
NUMPLOTS	-0.001	0.484	0.00	-0.092	0.522	-0.18
AREAMAIZ	0.282	0.223	1.26	0.426	0.268	1.59
SLOPE	0.121	0.430	0.28	-0.185	0.449	-0.41
GOOD	0.531	0.402	1.32	0.222	0.430	0.52
REMITTAN	0.271	0.431	0.63	0.510	0.454	1.12
CONS	0.280	1.643	0.17	-0.392	1.785	-0.22

Common support implementation

Before assessing the matching quality, it is important to check the overlap or common support region for adopters (1) and non-adopters (0). The most straightforward way is a visual analysis of the density distribution of the propensity score in both groups. The results can be found in figures F.1 to F.4. The left side of each group shows the propensity score distribution for the non-adopters, the right side refers to the adoption in each group. Taking for instance the results of maize hybrid adoption in Chiapas (figure

F.2), it can be seen that the distribution for non-adopters is highly skewed to the left. Problems arise when the distributions in both groups do not overlap.

There are several ways of imposing the common support condition; this analysis imposes the ‘minima and maxima’. The idea of minima and maxima comparison is to delete all treated observations, whose propensity score is smaller than the minimum and higher than maximum in the comparison group.

Figure 6.1: The common support

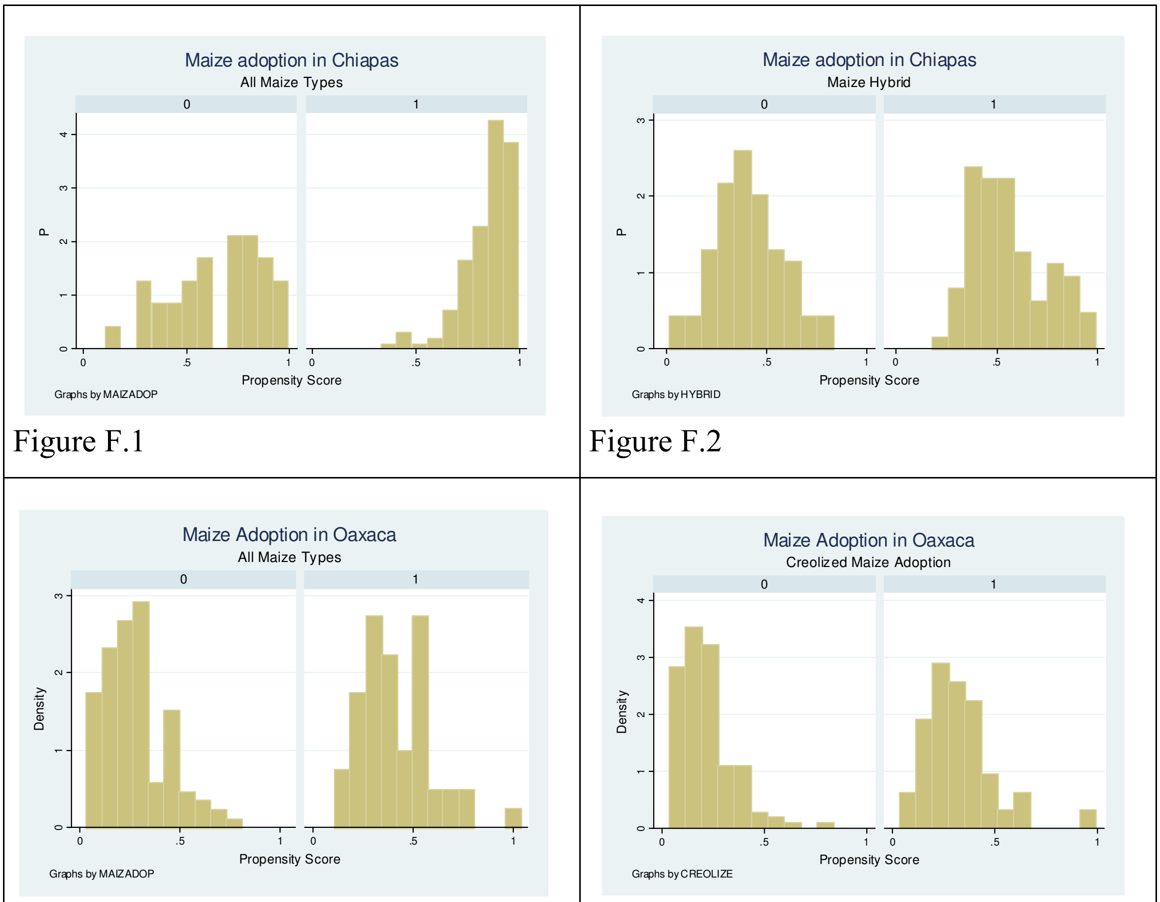


Figure F.1

Figure F.2

Figure F.3

Figure F.4

Choosing the matching algorithm

The technological effect on household PCE of rural households is estimated thorough two different methods, i.e., the nearest neighbor (NNM) and kernel-base matching (KBM) methods. For NNM eleven different algorithms were implemented and for KBM three different algorithms were implemented, all the results are in Appendix A.3 in Tables A.10 to A.17. For simplicity one of the eleven algorithm results for NNM and one of the three algorithm results for KBM are presented in Table 6.6. Overall, matching estimates show that improved maize varieties adoption has a positive and robust effect on household PCE and hence eradicating of poverty.

In NNM causal-effect of any improved maize variety adoption on household wellbeing is highly significant and equal to about MX$ 145 (or US$ 16) in Chiapas and MX$ 174 (US$ 19) in Oaxaca, which is the average difference between PCE of similar pairs of households but belonging to different maize variety status (specifically maize landraces). The matching procedure applied to the probability of the household to be poor (dependent variable equal to one if the household PCE falls below the poverty line) leads to the result that adopters are less likely to be poor by on average 24% as compared to non-adopters.

Table 6.6: PSM results for all improved maize varieties adoption on PCE and poverty.

	All *Improved maize varieties* adoption in Chiapas		All *Improved maize varieties* adoption in Oaxaca	
	NNM [a]	**KBM** [b]	**NNM** [c]	**KBM** [d]
Per-Capita Expenditure MX$:	**144.59**	**133.68**	**173.94**	**181.07**
	(2.65)**	[2.86]***	(1.76)*	[1.94]*
Food Poverty %:	**-23.9**	**-22.4**	**-24.0**	**-18.3**
	(-1.72)*	(-1.58)	(-1,86)*	(-1.66)*
Off common support:	*11*	*15*	*2*	*2*
Observations				
Treated (*Adopter*):	119	115	50	50
Controls (*Counterfactual*):	32	32	111	111

t-test in parenthesis: Significant at: * 10% , ** 5% *** 1% level.
z-bootstrapped in square bracket.
Algorithm selected:
[a]: NNM Oversampling 2.
[b]: KBM with bandwidth 0.03, Bootstrapped statistics 50 replications.
[c]: NNM with replacement and Caliper 0.05.
[d]: KBM with bandwidth 0.03, Bootstrapped statistics 100 replications.

In search of more precise estimates of the ATT causal-effect, the analysis estimates are broken down by maize type. In this case, the analysis attempts to account for the fact that maize hybrid has vigorous yield than maize OPV or creolized. The results in Table 6.7 shows that the new ATT are more precise and robust and therefore they are among the best set of estimates.

Table 6.7: PSM results for maize hybrid and creolized adoption on PCE and poverty.

	Maize-***Hybrid*** adoption in Chiapas		Maize-**Creolized** adoption in Oaxaca	
	NNM [a]	**KBM** [b]	**NNM** [a]	**KBM** [b]
Per-Capita Expenditure MX$:	**118.85**	**141.00**	**189.02**	**218.44**
	(2.25)**	[2.50]**	(2.08)**	[1.78]*
Food Poverty %:	**-7.40**	**-3.30**	**-21.1**	**-18.6**
	(-0.65)	(-0.36)	(-1.75)*	(-1.83)*
Off common support	*9*	*9*	*1*	*2*
Observations				
Treated (*Adopter*)	68	68	38	37
Controls (*Counterfactual*)	85	85	124	124

t-test in parenthesis: * Significant at 10% level, ** 5% *** 1% level.
z-bootstrapped in square bracket.
Algorithm selected:
[a]: NNM with replacement and Caliper 0.05.
[b]: KBM with bandwidth 0.03, Bootstrapped statistics, 50 replications.

The ATT causal-effect for maize hybrid in Chiapas is statistically significant under the two alternative estimation methodologies and it oscillates between the two cases. In the first case, NNM, is approximately MX$ 119 (US$ 13), whereas in the second case, KBM, is roughly MX$ 141 (US$ 15). But in this case looks like the impact on poverty has not effect, the interpretation is that in this case the analysis considers only farmers who adopt maize hybrids, and the control group are the farmers who plant another maize varieties, like OPVs and Creolized. The coefficient of food-poverty has the expected sign although is not significant.

Regarding maize adoption in Oaxaca, the maize creolized variety contributes more to better wellbeing in the small-scale farmer's households. The ATT effect is significant and range between the two methods. In the first case, NNM is approximately MX$ 189 (US$ 20), while in the second case, KBM, is roughly MX$ 218 (US$ 23). The result also shows that maize creolized adopters are less likely to be poor on average 20% points.

Assessing matching quality

Estimating the absolute bias between the respective adopter and non-adopter farmers before and after matching took place. The analysis calculates the means of the Standardized Bias (SB) before and after matching for the all improved maize varieties adoption and for maize hybrid and creolized adoption. For NNM eleven algorithms and KBM three algorithms were implemented, all these results are in Tables A.18 and A.19 in the appendix. For simplicity one algorithm is presented in Table 6.8.

Table 6.8: PSM quality.

Improved maize variety adoption	Simple	Pseudo R^2	Loglikelihood Ratio: chi2	p>chi2	Mean of Standardised bias
All improved maize varieties	Before match	0.166	26.80	0.005	19.6185
adoption in Chiapas **[a]**	After march	0.045	14.85	0.189	14.7502
All improved maize varieties	Before match	0.117	23.92	0.021	20.1663
adoption in Oaxaca **[b]**	After march	0.034	4.75	0.966	7.4540
Maize hybrid adoption	Before match	0.118	26.55	0.005	17.9109
in Chiapas **[b]**	After march	0.020	3.76	0.977	5.6812
Maize creolized adoption	Before match	0.109	19.56	0.076	18.9038
in Oaxaca **[b]**	After march	0.054	5.72	0.930	13.6548

Algorithm selected:
[a] NNM Oversampling 5 and common support
[b] NNM with replacement and Caliper 0.05

According to Table 6.8 the overall bias before matching lies between 18% for maize hybrid adoption in Chiapas and 19% for maize creolized adoption in Oaxaca. A significant reduction can be achieved for NNM, so the bias after matching is 6% for maize hybrid adoption in Chiapas and 14% for maize creolized adoption in Oaxaca. This is a considerable reduction and shows the matching procedure, for some algorithms, is able to balance the characteristics in the treatment and the matched comparison group.

Re-estimating the propensity score on the matched sample (i.e., on adopters and matched non-adopters) and compare the pseudo R^2's before and after matching for all NNM eleven algorithms and KBM three algorithms are in Tables A.18 and A.19 in appendix. For some matching algorithms there should be no systematic differences in the distribution of the covariates between both groups. Therefore, the pseudo R^2 after matching should be fairly low. As the results in Table 6.8, indicates a joint significance of all regressors before but no after.

6.3.2 Sensitivity analysis

PSM are not robust against “hidden bias” arising from the existence of unobserved variables that simultaneously affect assignment to treatment (adoption) and the outcome variable (PCE). One strategy for addressing this problem is the Rosenbaum bounds approach, which allows the analyst to determine how strongly an unmeasured confounding variable must affect selection into treatment in order to undermine the implications of a matching analysis (Diprete and Gangl, 2004).

Sensitivity analysis is based on bounds method developed by Rosenbaum (2002) and the methodology is taken form DiPrete and Gangl (2004). To assess the impact of hidden bias Rosenbaum suggest the computation of sign-score statistic, particularly Wilcoxon’s signed rank test. The sign-score statistics have the form:

$$T = t(Z,r) = \sum_{s=1}^{S} d_s \sum_{i=1}^{2} c_{si} Z_{si} \qquad (6.1)$$

where Z is the variable that registers which of each of the s pairs was treated, and r measures the outcome (PCE) for each case in the S pairs. Z_{si} equals 1 if a case is treated (adoption), and 0 otherwise (non-adoption). “c” is defined as follows:

$c_{si} = 1, c_{s2} = 0 \;\; if \; r_{s1} > r_{s2}$

$c_{si} = 0, c_{s2} = 1 \;\; if \; r_{s1} < r_{s2}$

$c_{si} = 0, c_{s2} = 1 \;\; if \; r_{s1} = r_{s2}$

Finally, d_s is the rank of $|r_{s1} - r_{s2}|$ with average used for ties. The product of the *c* and *Z* variables cause pairs to be selected where the outcome (PCE) for the treatment (adopter) was greater than the PCE for non-adopter. The ranks of these cases are summed and compared to the distribution of the test statistic under the null hypothesis that the treatment has no effect.

In the case where the assignment to treatment is not random, the above test statistic can be bounded. Rosenbaum proposes that one assume that there is an unmeasured variable *u* that affects the probability of receiving the treatment. If we let π_i be the probability that the *i-th* unit receives the treatment, and *X* are the observed covariates that determine treatment and that also determine the outcome variable, then the following treatment assignment equation applies (Diprete and Gangl, 2004).

$$\log\left(\frac{\pi_i}{1-\pi_i}\right) = k(X_i) + \gamma U_i \tag{6.2}$$

where $0 \le U_j \le 1$

Rosenbaum shows that this relationship implies the following bound on the ratio of the odds that either of two cases are matched on *X* (or alternatively on the propensity score P(X) will receive the treatment

$$\frac{1}{\Gamma} \le \frac{\pi_{s,1}(1-\pi_{s,2})}{\pi_{s,2}(1-\pi_{s,1})} \le \Gamma \tag{6.3}$$

where *s* index the matched pair, *s*=1, … *S*, and $\Gamma = \exp(\gamma)$

Under the assumption that a confounding variable *U* exist, equation (6.1) becomes the sum of *S* independent random variables where the *s-th* variations d_s with probability

$$p_s = \frac{c_{s1}\exp(\gamma u_{s1}) + c_{s2}\exp(\gamma u_{s2})}{\exp(\gamma u_{s1}) + \exp(\gamma u_{s2})}$$

and equals 0 with probability $1 - p_s$. Define

$$p_s^+ = \begin{cases} 0 & if \quad c_{s1} = c_{s2} = 0 \\ \dfrac{\Gamma}{1+\Gamma} & if \quad c_{s1} \ne c_{s2} \end{cases} \quad \text{and} \quad p_s^- = \begin{cases} 0 & if \quad c_{s1} = c_{s2} = 0 \\ \dfrac{\Gamma}{1+\Gamma} & if \quad c_{s1} \ne c_{s2} \end{cases}$$

Rosenbaum shows that for any specific γ, the null distribution of $t(Z, r)$ is bounded by two known distribution for T^+ and T^- where

$$E(T^{+}) = \sum_{s=1}^{S} d_s p_s^{+}$$

$$E(T^{-}) = \sum_{s=1}^{S} d_s p_s^{-}$$

$$Var(T^{+}) = \sum_{s=1}^{S} d_s^2 p_s^{+}(1-p^{s})$$

$$Var(T^{-}) = \sum_{s=1}^{S} d_s^2 p_s^{-}(1-p^{-})$$

Then is possible to compute the significance level of the null hypothesis of no effect. For any specific Γ

$(T - E(T^{+}))/\sqrt{Var(T^{+})}$ and $(T - E(T^{-}))/\sqrt{Var(T^{-})}$

where T is the Wilcoxon signed rank statistic. These two values give bounds of the significance level of a one-side test for no effect of the treatment (Diprete and Gangl, 2004).

Under the assumption of an additive treatment effect, Rosenbaum (2002) also derives bounds on the Hodges-Lehmann point estimate of the treatment effect, enabling the researcher to frame the sensitivity analysis in the more common metric of an interval of point estimates rather than in terms of implied significance levels for the estimated treatment effect. To arrive at an interval of plausible point estimates given a specific bias level Γ, Rosenbaum defines the Hodges-Lehmann point estimate of the treatment effect

$$\delta = \frac{\inf\{\delta : t' > t(Z, Y - \delta Z)\} + \sup\{\delta : t' < t(Z, Y - \delta Z)\}}{2}$$

Though not generally known, the expectation of that signed rank statistic is bounded by the expectations of T^{+} and T calculated at

$t_{\min} = \frac{p^{-}S(S+1)}{2}$ and $t_{\max} = \frac{p^{+}S(S+1)}{2}$

where

$p^{-} = \frac{1}{1+\Gamma}$ and $p^{+} = \frac{\Gamma}{1+\Gamma}$

Since the bounds on the signed rank statistic are sharp, we can calculate an interval of point estimates consistent with these bounds by calculating the statistic at $t = t_{\max}$ and

$t = t_{\min}$. By similar reasoning, Rosenbaum also derives bounds for the confidence interval of the point estimate (Diprete and Gangl, 2004).

Tables A.20 to A.23 (in appendix) show the results of NNM for eleven algorithms and KBM for three algorithms imposed and the p-value from Wilcoxon sign-rank tests for the ATT while setting the hidden bias to a certain value of Γ[18], reflects the assumption about unmeasured heterogeneity in treatment assignment is expressed in terms of the odds ratio of differential treatment assignment due to an unobserved covariate. At each Γ the analysis calculates a hypothetical significance level "p-value", which represents the bound on the significance level of the treatment effect in the case of endogenous self-selection into treatment status. By comparing the Rosenbaum bounds on treatment effects a different levels of Γ one can assess the strength such unmeasured influences would require in order that the estimated treatment effects from PSM would have arisen purely through selection effects.

For simplicity Table 6.9 shows that robustness to hidden bias varies considerably across the overall improved maize varieties adoption and for maize hybrid and creolized adoption.

It is important to recognize that these results are worst-case scenarios. For instance a value for all improved maize varieties adoption in Oaxaca and Γ = 1.4 does not mean that there is no true positive effect of improved maize adoption on PCE at 5% level of confidence (p-value = 0.0595). This result means that the confidence interval for the technology adoption effect would include zero if an unobserved variable caused the odds ratio of treatment assignment to differ between adopters and non-adopters farmers by 1.4 and if this variable affect on PCE was so strong to perfectly determine whether the PCE would be bigger for the adopters or the non-adopters case in each pair of matched cases in the data.

One can see that the robustness to hidden bias varies considerable across maize variety adoption and region selected. The finding of positive effect of creolized maize adoption

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[18] The STATA © *rbounds* program was used developed by Markus Gangl (Social Science Centre Berlin [WZB]).

is the least robust to the possible presence of selection bias. The critical level of Γ at which one would have to question our conclusion of a positive effect is between 1.15 and 1.4, i.e., if an unobserved covariate caused the odds ratio of treatment to differentiate between treatment (adoption) and control (non-adoption) cases by a factor about 1.4.

Table 6.9: ATT effects for adopters and sensitivity analysis with Rosenbaum bounds.

Improved maize variety adoption	ATT*	Value of gamma (Upper Bounds reported)					
		1	1.1	1.15	1.4	1.6	2
All improved maize varieties	111.65	**59.20**	**48.21**	**42.98**	21.32	7.91	-14.04
adoption in Chiapas **[a]**	(p-value)	0.006	0.020	0.033	0.175	0.373	0.756
All improved maize varieties	173.94	**119.55**	**99.24**	**92.93**	**60.82**	41.79	17.68
adoption in Oaxaca **[b]**	(p-value)	0.005	0.012	0.016	0.059	0.120	0.294
Maize hybrid adoption in	118.85	**51.66**	38.01	30.73	7.35	-6.82	-33.02
Chiapas **[b]**	(p-value)	0.077	0.139	0.177	0.408	0.594	0.847
Maize creolized adoption	189.02	**134.82**	**121.76**	**112.38**	**82.35**	64.41	34.24
in Oaxaca **[b]**	(p-value)	0.009	0.016	0.022	0.065	0.120	0.264

* Common support imposed and MX$

Algorithm selected:

[a] NNM Oversampling 5 and common support

[b] NNM with replacement and Caliper 0.05

The Rosenbaum bounds are in this sense a “worst-case” scenario. Nonetheless, they convey important information about the level of uncertainty contained in matching estimators by showing just how large the influence of a confounding variable must be to undermine the conclusions of a matching analysis.

6.3.3 Maize adoption and poverty: discussion

These results highlight the potential role of improved germplasm in directly reducing poverty through the enhancement of per capita expenditure. According to the PSM estimation method, the adoption of improved germplasm of maize has a positive impact on farm household wellbeing. This method leads to quantification of the positive impact of technology adoption on resources-poor farmers, in terms of rise in per capita expenditure and poverty reduction.

Furthermore, these findings differentiated by maize-type show that potential gains from maize hybrid are positive and significant for small-scale farmers in Chiapas, and gains from creolized maize are also positive, robust and significant for small-scale farmers in Oaxaca.

These findings are very close to Bellon et al. (2006) contribution. They carried out a study of farmers' assessment of different maize types (hybrid, OPV, creolized and landrace) evaluating: (a) the importance farmers assign to different maize traits, (b) farmers' perceptions of the extent to which different germplasm types supply those traits, and (c) the trade-offs they perceive among the different germplasm types. Their evaluation consisted of two parts: (1) an assessment of the importance to farmers of the identified traits, in which males and females rated each trait as very important, important, or not important, in terms of its relevance for choosing a maize variety; and (2) an assessment of farmers' perceptions of the performance of each variety they grew relative to each previously identified trait. Bellon et al. (2006) used a proportional odds model to systematically examine farmers' perceptions of the varieties' performance with respect to traits that farmers considered important. Bellon and colleagues ran the model independently for each of the 19 identified traits[19], separately for males and females, and individually for the two study areas (Chiapas and Oaxaca).

The main findings of Bellon and colleagues about farmers' perception are: small-scale farmers in Oaxaca perceived more advantages in creolized varieties than those in Chiapas. Oaxacan farmers perceived that creolized varieties provide traits that landraces

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[19] The 19 traits are grouped in three categories: a) *vulnerability*: (1) lodging resistance, (2) drought tolerance, (3) tolerance to excess rainfall, (4) ear rot resistant, (5) duration (growing cycle), (6) field pest resistant, (7) storage pest resistant, (8) produces even in a bad season (yield reliability), (9) good for sale, b) *consumption related*: (10) good for consumption, (11) good for "atole" (beverage), (12) good for "elotes" for sale and consumption, (13) food for "antojitos" (especial maize preparation), (14) easy of shelling, (15) good for "nixtamal" (boil), (16) good for fodder, c) *productivity*: (17) yield of "tortilla" dough, (18) yield by weight, (19) yield by volume.

do not, as well as useful combinations of traits that reduce some of the trade-offs between landraces and hybrids. In Chiapas, they found that males perceived maize hybrids to have many advantages compared to other types of germplasm available. Farmers in Chiapas rated hybrids higher than OPVs (in particular), and hybrids for several traits (related to consumption and marketing characteristics). However, OPVs, creolized, and landraces varieties were rated higher than hybrids when it came to storage pest resistant, a key trait for subsistence farmers. Lastly, female perceptions for hybrids were rated high for yield reliability compared to other types of improved germplasm.

Chapter 7
Conclusions and Implications

The analyses conducted in this study aimed at examining household factors for improved germplasm adoption and maize biodiversity conservation, as well as the impact of maize technology adoption on poverty alleviation in Chiapas and Oaxaca, Mexico. Due to the constraints posed by poverty, the study was partly intended to contribute towards designing of appropriate government programs in the direction of sustainable agricultural development, as well as sustainable maize breed improvement programs aimed at encouraging the adoption and use of high yielding varieties. The main motivation for studying the households' maize technology adoption behavior and maize biodiversity conservation is the potential contribution of breed programs and government policy interventions in improving maize productivity and enhancing food security and poverty alleviation in subsistence oriented farming systems. The primary benefit from improved maize germplasm is a significant enhancement in the livelihoods of maize producers through per capita expenditure effect. The study further aimed to identify potential factors that contribute to maize technology adoption, as well as factors that contribute to maize biodiversity conservation on farmers' fields. This chapter summarizes the impetus of the study along with a review of the methods used. A summary of the results is then presented along with the implications of the results on policy. Lastly suggestions for future research in the country are discussed.

7.1 Study focus and review methods

Agricultural technology adoption studies, particularly modern maize varieties often focus on dichotomy variables approaches utilizing modern versus traditional maize varieties. This often ignores the continued maize types like hybrids, OPVs, creolized and landraces. These varieties have different important traits, prices and performance for maize producers, especially small-scale farmers. In this study, a range of maize types was identified through focus group discussion and maize collection in the study area. A binary Probit model was employed to assess the household factors that influence improved germplasm adoption on a random sample of 325 maize producers households in Chiapas and Oaxaca, Mexico.

Few small-scale farmers have adopted improved germplasm in Oaxaca; consequently, a count Poisson model was employed to assess the crop diversity conservation on farm fields.

The study also focused on identifying the potential impact of maize technology adoption on poverty alleviation. Given that it is not possible to observe a small-scale household before and after maize technology adoption with cross section data set, as well as using a standard methodology is unable to identify the *causal-effect* of maize adoption on poverty. The study then followed a propensity score matching approach that allow to compare maize technology adopting households with households that do not adopt modern germplasm but that have observable characteristics that are similar to those who do. After matching the households in this manner, there is the possibility to compute the effect of maize adoption. This effect takes the form of an "average treatment on the treated" effect, where the treatment is taken as whether a household adopts maize technology or not. For robustness purposes, the analysis uses two alternative methods of estimation of the average treatment effect (i.e., nears neighbor matching and kernel based matching methods). As well as sensitivity analysis convey important information about the level of uncertainty contained in matching estimators by showing just how large the influence of a confounding variable must be to undermine the conclusions of a matching analysis.

7.2 Summary of results and implications for policy

The overall results suggest that there is a dilemma between maize biodiversity conservation and poverty reduction. As Smale (2006: p. 6) points out "[…] Economics principles suggests that as an economy changes, maintaining intracrop diversity on farms should occur to the extent that trade-offs between productivity and diversity maintenance are consistent with social preferences."

The summary of results is discussed under three main sub-sections: maize technology adoption, maize biodiversity conservation, and impacts of maize technology adoption on poverty alleviation.

7.2.1 Maize adoption

Firstly, one of the major findings is that both regions are highly contrasting; Oaxaca has a subsistence oriented farming system; where small-scale farmers trade at least 10% of their maize production. The farmers conserve crop genetic resources into the traditional *Milpa* system. Consequently the rate of maize adoption is very low. Chiapas has a commercial oriented farming system, where farmers trade more than 90% of their maize harvest. In both regions these two systems (modern and traditional) co-exist but the traditional, subsistence oriented farming systems is much more widely distributed in Oaxaca than Chiapas. Therefore maize farmers are highly heterogeneous, intra and inter, in the two regions. These findings are in agreement with Brush and Chauvet (2004) about the Mexican maize agriculture characterization. Surprising, poverty is pervasive in both study areas, even in the more commercialized and developed Chiapas.

Secondly, the empirical results from binary *Probit* model provide several insights to understand maize farmers' adoption behavior. The results from the *Probit* model revealed significant socioeconomic farmers' characteristics that contribute to maize adoption among maize farmering households.

Reviewing the results for Chiapas, the households' socioeconomic characteristics (age, share of male member between 15 and 50 years old, horse as animal capital asset, farm size and land quality) strongly influence the likelihood of improved germplasm adoption. All this variables are in agreement with agricultural technology adoption theory. Surprising was the coefficient's on the PROCAMPO variable sign, probably due to the fact that the subsidy is invested in other household's priorities. As many small-scale farmers opine, in voice of them: the resources came late, after the land preparation and plant season, we use the resources–or cash–to buy households appliance. Quite significant and interesting was the finding that staple crops decrease the likelihood of maize adoption. That is, if the farmers interplant with maize minor crops like beans, squash and chili, this reduces the likelihood of modern maize variety adoption probably due the requirement needed to raise yield such as increasing the seed-rate, and that maize seed hybrids must be planted in high-density populations, i.e., number of plants by area. Normally, the seed rate has to be in the range of 20 and 25 kilograms of maize seed by hectare. And obviously, if the farmer wants to inter plant maize with minor crops he has to reduce the seed rate.

In Oaxaca, quite significant and interesting was the findings that non-indigenous farmer and remittances increase the likelihood of maize adoption. This is probably because most of the non-indigenous inhabitants speak and understand Spanish, and the majority of the maize technology information is in Spanish as well. There is no report about official extension programs or media information in native language available. Furthermore, the statistical analyses show that the majority of indigenous farmers are poor. As Kerr and Kolavalli (1999) argued "Quantitative and qualitative methods are highly complementary because their strengths correspond to different aspects of the research problem." In this way, the farmers' opinion about ability to speak Spanish is that being indigenous is strongly correlated with poverty, because native people do not speak Spanish. If they cannot speak few words is not possible to get a job or trade in the market. Another interesting finding is that remittances play a key role in maintaining the rural life ongoing. The evidence suggests that cash transfer from abroad increase the probability of maize technology adoption. In the words of local farmers: remittances are effective, they arrived on time, much earlier than the government subsidy.

7.2.2 Maize biodiversity conservation

The households' socioeconomic constraints are characteristics that significantly motivate farmers to manage a portfolio of local maize varieties, beans and squash into the *Milpa* system. Old age and indigenousness of the household head, number of maize purposes or uses, land fragmentation, intensity of human capital farming, and poor soil quality explain significantly and strongly the subsistence oriented farming. These factors suggest that poor farmers conserve the maize biodiversity on-farm; subsistence agriculture has been associated before with crop diversity (Brush, 1986). Many researches and scholars have been hypothesized that: if imported maize prices remain near or below cost of production in Mexico, it is likely that Mexico's own maize growing will decrease substantially and rapidly (Nadal, 2000; Goodman and Barrios, 2004). The thesis's results show that poor farmers still plant maize for their livelihoods, maize landraces and creolized varieties play a key role offering the cheaper seed option such as input, additionally beans and squash are intercropping into the *Milpa* system.

Quite interesting was the results of ethnicity and number of purposes for which maize is used in the household. This is probably due to the fact that native rural inhabitants remain in villages. Furthermore, they have strong connection between traditional knowledge and maize landraces as Brush and Chauvet (2004) pointed out. The number of purposes for which maize is used in the household, is in agreement with Morris (1998) who argues "once consumer incomes rise above a certain threshold level, direct human consumption of maize declines with additional growth in income. Above the threshold income level, consumers respond to additional increases in purchasing power by consuming less maize and greater quantities of higher-priced luxury foods, especially meat and dairy products, fruit, and vegetables." And *vise versa*, poor farmers demand more maize varieties and minor crops, beans and squash on order to ensure their food livelihood.

Remittances are a threat to maize biodiversity conservation. It was noted that the coefficient on this variable was not significant, but its sign suggests that if remittances increase, this reduces the likelihood of *Milpa* conservation. The variable is highlighted because in the binary *Probit* model for maize adoption it is significant for the same region (thinking as inverse of maize conservation). Pressures on maize diversity have been existed for many years, the introduction of modern maize varieties, maize grain and seed imports after signing NAFTA, and dissemination and introgression of maize transgenic into the maize landraces. The current pressure on maize producers, especially migration and remittances pose greater and more immediate threats to maize diversity.

According to propensity score matching analyses, non-adopters (who are maize conservers *de-facto*, van Dusen (2000)) show a negative and significant difference in per capita expenditure (as inverse of overall maize technology adoption), i.e., they are poor than improved germplasm adopters.

Lastly, the analyses results are very close to van Dusen (2000) findings in *Sierra Norte de Puebla*,–central east–Mexico. The evidence suggests that the poverty forces small-scale farmers to come back to subsistence farming system. This idea is in agreement with de Janvry et al. (1991) who argued that in absence of markets, farmers attain their households' objectives autarkically, as this is the case; farmers have to find their own internal mechanism of dealing with any households needs. In the same direction, Dyer and Yunez-Naude (2003) argued that there is widespread conviction that *de-facto* conservation of crop genetic resources is inversely associated with economic development, and particularly with market integration. The scope of that association between conservation and development was very wide, as it included the development of goods, services, and factor markets, as well as basic infrastructure.

7.2.3 Improved germplasm adoption and poverty alleviation

The study is well suited to shed light on the discussion of whether maize adoption helps the poorest farmers or not. The analysis highlights the potential role of maize technology adoption in directly reducing poverty through enhancement of small-scale farmer's per capita expenditure.

The maize hybrid adoption in Chiapas, and maize creolized adoption in Oaxaca have a positive impact on farm household livelihood. The PSM leads to quantification of the positive impact of maize adoption in terms of rise of per-capita expenditure, and consequently on poverty reduction. Therefore, these results strongly suggest that improved germplasm is an important mechanism to help rural households to get out of poverty (food-poverty).

These results are very close to Bellon et al. (2006) findings in Chiapas and Oaxaca, as well. But, Bellon and colleagues assess farmers' perceptions about the attributes of different maize types. Their findings show that farmers in Chiapas perceived hybrid had many advantages compared to other maize types available. The hybrid traits are related to consumption and marketing characteristics. Farmers in Oaxaca perceived that creolized varieties provide traits that landraces do not, as well as useful combinations of traits that reduce some of the trade-offs between landraces and hybrids, the creolized traits are lodging resistance and yield by weight. Worthwhile to take note is that in their model, households derive utility from the crop's traits or attributes, rather than from the crop itself.

7.3 Directions for future research

The main objective of this study was to assess the impact of maize technology adoption on poverty reduction in subsistence oriented systems maize producers of Chiapas and Oaxaca, Mexico. Twelve villages were selected in south Mexico to represent small-scale farmers' subsistence oriented systems. The causal-effect derived from positive difference per capita expenditure reflects the relative importance of the modern germplasm adoption.

The study was carried out using cross-sectional questioner data and provides interesting results on economic impact of maize adoption households. It may be interesting to further investigate whether the causal-effect are time variant, especially as agricultural policy reforms which influence the small-scale farmers behavior are inherently characterized by crisis fluctuations.

Technology development for agriculture under less favorable conditions has to be attended by breeding programs IARCs and NARSs as well as in the government policy agenda. This thesis shows that conditions are spatially diverse; sometimes technologies need to be tailored to suit different conditions.

The fieldwork experience shows that participatory research also aims to take advantage of farmer's knowledge and capability to experiment. One idea could be that farmers actively use their knowledge to evaluate different improved germplasm. That is, the aim of participatory agricultural research is to jointly identify problems and opportunities, identify a number of options based on indigenous knowledge and formal science, obviously it has to be multidisciplinary work.

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Appendix A

This appendix demonstrates two alternative econometric techniques for modeling improved germplasm adoption. Subsection A.1 provides the econometric specification and results for Multinomial-Logit model for Chiapas and Oaxaca. Subsection A.2 presents the econometric requirement and results for Ordered-Probit model, for the two regions. Each econometric result is followed by a brief economic interpretation. Subsection A.3 portraits all the results of propensity score matching. Lastly, section A.4 concludes the appendix explaining why these two econometric techniques are not suitable for maize adoption modeling reported in this thesis.

A.1 Model specification for Multinomial-Logit

An adoption decision by farmers is inherently a multivariate decision. As the empirical information shows in Table 5.1 (above, Chapter 5) or Table A.1 (below), there is a spectrum of maize types and combination among them, i.e., many farmers make a portfolio of selected maize types, tacitly looking for their utility maximizing. Therefore, it is appropriate to treat adoption of maize types as a multiple-choice decision. The Multinomial-Logit model has been chosen for this appendix section in order to show another alternative modeling of maize adoption. The model determines the factors influencing selection of maize types in the context of individual household's multiple choices. The unit of observation and analysis for this section is farmers' individual maize type selection or combination among maize types. In the Multinomial-Logit model specification the maize types chosen by farmers are classified and ordered according to the extent of improved germplasm content.

Multinomial-Logit model can be used to estimate a utility maximization problem where the farmer is assumed to have preferences defined over a set of technology alternatives:

$$U_j = \phi_j' z_i + \varepsilon_j$$

where U_j is the utility of technology j, z_i a vector of household, farm and government programs characteristics ($\Psi_{HH}, \Psi_{Farm}, \Psi_{Gprogram}$, respectively), ϕ_j a conformable vector of parameters to be estimated and ε_j the disturbance term. The disturbance terms are assumed to be independently and identically distributed. If a farmer '*i'* chooses alternative j to other maize types, then it is assumed that the utility from alternative j is greater than the utility form other alternatives, i.e.,

$$U_{ij} > U_{ik}\text{, for all } k \neq j$$

where U_{ij} is the utility to the i-th farmer of technology j, and U_{ik} the utility to the i-th farmer of technology k. The farmer's utility from choosing a specific maize type is not observable but his or her choice of a maize type is. When farmers think of each technology as a possible adoption decision, then the farmer will be expected to choose the technology that has higher expected utility among the alternatives considered or possible combinations among alternatives, i.e., farmers make a maize portfolio selection.

The probability of choosing alternative j from J alternative choices is equal to the probability that expected utility from alternative j is greater than the expected utility from any other alternative, i.e.

$$\Pr(C = j) = \Pr[E(U_j) - E(U_k) > 0] \text{ for all } k \neq j$$

where C denotes the choice of specific maize type portfolio according to Table A.1.

Following Greene (2003) and Bekele and Drake (2003), if the residuals ε_j are independent an identical with extreme value type I distribution, then a Multinomial-Logit model can represent the choice of maize type:

$$\Pr(y = j) = \frac{e^{\phi_j z_i}}{e^{\phi_0 z_i} + e^{\phi_1 z_i} + \cdots + e^{\phi_j z_i}}$$

The Multinomial-Logit model is widely used in economic applications, including the study of the choice of transportation modes, occupations, asset portfolio, and the number of automobiles demanded. The main limitation of the Multinomial-Logit model is the assumption of independence of irrelevant alternatives (IIA). This assumption states that the relative choice probabilities for any two alternatives are independent of the other choices available. This is a convenient property with regards to estimation, but it is often an unappealing restriction to place on farmer behavior (Wu and Babcock, 1998). One alternative to the Multinomial-Logit model is the Nested-Logit model, which can be derived from the assumption that the residuals ε_j in the utility functions have a generalized extreme value distribution (Greene, 2003). Although this model is computationally tractable, it requires specification of a nesting structure or sequence of decisions on the choices, which is less meaningful in this study's context. One possibility could be the Ordered-Probit model[20] (presented in the following section A.2).

The first exercise tests for all possible maize type combinations through Multinomial-Logit model estimation. All possible maize type combinations are presented in Table A.1. In this estimation the Multinomial-Logit analysis fails as there is insufficient variation in the dependent variable. Error "*806* if it happens in the first iteration, the model is probably inappropriate for this data set" and error "*135*: Models Hessian during Newton iterations" (LIMDEP© 8.0 & NLOGIT© 3.0, 2002). Similarly, according to Greene (2003: p. 722) "it is worth noting that the number of parameters in this model (Multinomial-Logit) proliferates with the number of choices, which is unfortunate because the typical cross section sometimes involves a fairly large number of regressors."

Table A.1: All maize types combinations, derived from Table 5.1

All maize types combinations			Frequency (a)			
New Number	Old Number		Chiapas	%	Oaxaca	%
0	1	Hybrid	33.0	20.4	4.0	2.5
1	13	OPV	23.0	14.2	2.0	1.2
2	5	Hybrid & OPV	8.0	4.9	-	-
3	7	Hybrid, OPV & Creolized	1.0	0.6	-	-
4	6	Hybrid, OPV & Landrace	3.0	1.9	-	-
5	3	Hybrid & Creolized	10.0	6.2	-	-
6	4	Hybrid, Creolized & Landrace	3.0	1.9	-	-
7	2	Hybrid & Landrace	19.0	11.7	7.0	4.3
8	15	OPV & Creolized	3.0	1.9	-	-
9	14	OPV & Landrace	3.0	1.9	-	-
10	11	Creolized	22.0	13.6	30.0	18.4
11	12	Creolized & Landrace	2.0	1.2	9.0	5.5
12	10	Landrace	32.0	19.8	111.0	68.1
(a) Number of household-farm			N=162	100	N=163	100

Source: survey data 2001

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[20] The author attended the conference: "Economía y ambiente" in Mexico, in November 2006, and presented some preliminary thesis results. There the panel suggested estimating the *Ordered-Probit* model, as measure of preferences for high yield maize varieties versus low yield varieties.

The second step was categorizing all the feasible combinations in four classes, the classification was according to yield performance, in line with the deliberations in section 4.2.3 and Figures 4.3a and 4.3b (above). Table A.2 shows the dependent variable, where it takes the following values: 0) if the farmer uses only landraces, 1) only uses creolized maize varieties, 2) if farmer keeps different maize germplasm types, and 3) if farmer plants maize hybrid, OPVs or both.

Table A.2: All maize types combinations, derived from Table A.1

All maize types combinations		Frequency (b)			
Number(a)		Chiapas	%	Oaxaca	%
0	Landrace	32.0	19.8	111.0	68.1
1	Creolized	22.0	13.6	30.0	18.4
2	Keep different germplasm	44.0	27.2	16.0	9.8
3	Hybrid, OPV or both	64.0	39.4	6.0	3.7
		N=162	100	N=163	100

Source: survey data 2001. (a) Numeration for dependent variable.
(b) Number of household-farm

Tables A.3 to A.5 present the results for Multinomial-Logit for Chiapas and Oaxaca.

The Multinomial-Logit parameter coefficients ϕ are difficult to interpret (Greene, 2003: p. 722), so the marginal effects of explanatory variables z_i on the choice of maize type are derived.

Table A.3 below shows the Multinomial-Logit results for the relationship between maize type selection and the explanatory factors for Chiapas region. In this model, the explanatory factors were significant at the 5% and 10% levels. The log likelihood chi-square value of 109.63 was significant at 1% (p-value ≈ 0.0000) level of significance. The pseudo R-square was 0.2578 and a moderate prediction of 53.1% for the maize type choice was achieved.

The marginal effects for maize type choice show that age has unexpected coefficient sign for maize hybrid and OPV selection, although it has the expected sign for maize landrace choice. The coefficient for education in all possible maize type choices is not statistically significant, although it has the expected sign in all cases. These two variables are considered key factors in the adoption theory (as human capital). But, these results do not make economic sense.

Table A.3: Multinomial-Logit marginal effects for maize types adoption for Chiapas

Variable	**Prob[Y=0] Landrace**			**Prob[Y=1] Creolized**		
	Coefficient	T-Ratio	Sig.	Coefficient	T-Ratio	Sig.
Constant	-0.379	-2.319	**	0.039	0.279	
Households characteristics						
AGE	0.003	1.820	*	-0.002	-1.089	
EDUDUMMY	-0.092	-1.454		-0.072	-1.272	
HHSIZE	0.035	2.478	**	0.001	0.081	
SHAM1550	-0.005	-2.402	**	0.000	0.239	
STAPLEC	0.060	2.397	**	-0.045	-1.559	
HORSE	-0.125	-2.538	**	-0.025	-0.947	
REMITTAN	-0.065	-0.566		-0.013	-0.220	
DISTANCE	0.004	2.103	**	0.004	2.541	**
Farm characteristics						
LANDOWNER	-0.211	-1.664	*	0.018	0.199	
NUMPLOTS	0.058	1.493		0.052	1.533	
AREAMAIZ	-0.022	-1.697	*	-0.034	-2.661	***
ARED	-0.020	-0.865		-0.025	-1.166	
SLOPE	0.109	1.958	*	-0.121	-2.315	**
Government programs						
SUBSIDY	0.192	1.580		0.005	0.062	
SEEDX	-0.079	-1.139		0.052	1.093	
ACCESEXT	-0.042	-0.796		0.029	1.164	

Variables	**Prob[Y=2] Diff germplasm**			**Prob[Y=3] Hybrid & OPV**		
	Coefficient	T-Ratio	Sig	Coefficient	T-Ratio	Sig
Constant	-0.206	-0.634		0.546	1.662	*
Households characteristics						
AGE	-0.005	-1.446		0.003	0.936	
EDUDUMMY	0.159	1.184		0.005	0.041	
HHSIZE	-0.047	-1.928	*	0.010	0.418	
SHAM1550	0.004	1.175		0.001	0.333	
STAPLEC	-0.002	-0.043		-0.013	-0.241	
HORSE	0.114	2.111	**	0.036	0.590	
REMITTAN	0.072	0.499		0.006	0.038	
DISTANCE	-0.002	-0.688		-0.006	-1.947	*
Farm characteristics						
LANDOWNER	0.084	0.392		0.109	0.512	
NUMPLOTS	0.159	2.531	**	-0.269	-3.594	***
AREAMAIZ	0.013	0.714		0.044	2.056	**
ARED	0.003	0.099		0.042	1.257	
SLOPE	0.013	0.138		-0.001	-0.012	
Government programs						
SUBSIDY	0.011	0.068		-0.208	-1.221	
SEEDX	0.023	0.245		0.004	0.038	
ACCESEXT	0.034	0.556		-0.021	-0.295	

*** significant at <0.01; ** significant at <0.05; * significant at <0.1

Labor availability in the household, measured by proportion of male family members aged 15-50 years, has the expected coefficient sign for maize landrace choice, whilst for maize high yielding selection the coefficient has the expected sign but is not significant. Distance and area planted with maize – two of the 16 variables – have the expected sign and are statistically significant, i.e., these variables are in agreement with adoption theory. If the distance increases, the likelihood of improved germplasm choice decreases. Inversely for farmers who choose maize landraces, if the distance increases, the likelihood to choose local varieties increases as well. Similarly, the results for area planted with maize (as proxy of farm size) show that large farmers are more likely to choose high yielding varieties, whereas small farmers are more inclined to select landraces or creolized varieties.

It was not possible to obtain results for Oaxaca, because there are only six farm households who adopt maize hybrid and OPV. According to Table A.2 there are six observations for maize hybrid and OPV selection. The alternative, once again, was categorizing the dependent variable by farmers' maize type choice. Table A.4 presents the new dependent variable for Oaxaca, where 0) is for farmers who only plant maize landrace, 1) if the farmer uses only creolized maize, and 2) if farmers plant different maize germplasm.

Table A.4: All maize types combinations derived from table A.2

All maize types combinations		Frequency (b)	
Number (a)		Oaxaca	%
0	Landrace	111.0	68.1
1	Creolized	30.0	18.4
2	Keep different germplasm	22.0	13.5
(a) Dependent variable number		N=163	100

(b) Number of household-farm

Table A.5 below shows the Multinomial-Logit results for the relationship between maize type choice and the explanatory factors for Oaxaca. In this model, the explanatory factors were significant at the 5% and 10% levels. The log likelihood chi-square value of 62.387 was significant at the 1% (p-value ≈ 0.00411) level of significance. The pseudo R-square was 0.2269 and a moderate prediction of 71.17% for the maize type choice was achieved.

Few variables have the expected sign and significance level in the analysis made for Oaxaca. This is essentially because of the region's feature that there are only few farm households who adopt modern maize varieties. According to Table A.4 the majority of farm households plant maize landraces, approximately 70%.

Four of the eighteen variables have the expected sign and are statistically significant; i.e., ethnicity, share of male members aged 15 to 50 years, remittances and good soil quality behave in agreement with adoption theory. If the farmer is indigenous, there is a higher probability to choose maize landrace; and inversely non-indigenous farmers are more likely to select creolized or high yielding varieties (but the coefficient for high yielding varieties is not significant). The result also suggests that if the family labor increases, the likelihood to choose improved germplasm increases, and less family labor increases the preference for maize landraces. If the farmer does not receive remittances, then he or she is inclined to planting land races. As expected, farmers who reported remittances are more likely to choose creolized maize and high yielding varieties (but the last one is not significant). Lastly, if the farmer owns land with good soil quality, it is more likely that he/she selects improved germplasm, while less soil quality increase the probability to select traditional varieties.

Table A.5: Multinomial-Logit marginal effects for maize type adoption for Oaxaca

Variables	**Prob[Y=0] Landrace**			**Prob[Y=1] Creolized**			**Prob[Y=2] Diff germplasm**		
	Coefficient	T-Ratio	Sig.	Coefficient	T-Ratio	Sig.	Coefficient	T-Ratio	Sig.
Constant	0.789	2.714	**	-0.322	-1.506		-0.467	-2.178	**
Households characteristics									
AGE	-0.001	-0.325		0.001	0.399		0.000	0.035	
EDUDUMMY	-0.045	-0.478		-0.017	-0.240		0.062	0.933	
ETHNICTY	-0.235	-2.960	***	0.171	2.740	***	0.064	1.221	
HHSIZE	-0.001	-0.034		0.011	0.897		-0.010	-0.855	
SHAM1550	-0.005	-1.675	*	0.001	0.361		0.004	2.205	**
STAPLEC	0.000	-0.005		-0.005	-0.138		0.005	0.189	
HORSE	-0.065	-1.579		0.046	1.606		0.020	0.698	
REMITTAN	-0.328	-1.795	*	0.244	1.964	**	0.084	0.644	
DISTANCE	0.004	1.800	*	-0.004	-2.422	**	0.000	0.078	
Farm characteristics									
LANDHOLD	-0.050	-0.458		-0.009	-0.123		0.060	0.721	
NUMPLOTS	0.005	0.057		-0.039	-0.547		0.034	0.599	
AREAMAIZ	-0.002	-0.048		0.031	1.368		-0.029	-0.668	
REDSOIL	-0.149	-1.448		0.156	2.079	**	-0.007	-0.097	
SLOPE	-0.101	-1.106		-0.006	-0.088		0.107	1.595	
GOOD	-0.187	-2.337	**	0.072	1.185		0.115	2.070	**
Government programs									
SUBSIDY	-0.056	-0.622		0.060	0.850		-0.004	-0.067	
SEEDX	0.100	1.004		-0.067	-0.892		-0.034	-0.491	
ACCEXTEN	-0.032	-0.357		-0.033	-0.458		0.065	1.133	

*** significant at <0.01; ** significant at <0.05; * significant at <0.1

A.2 Model specification for Ordered-Probit

Order-response models recognize the indexed nature of various response variables. In this application, maize type classes (based on yield difference, section 4.3.2) are the ordered response. Consequently, for this model specification, the dependent variable is considered as farmers' preference for high yield varieties (e.g., hybrid) against low yield maize varieties (e.g., landrace). Underlying the indexing in such models is a latent but continuous descriptor of the response. In an Ordered-Probit model, the random error associated with this continuous descriptor is assumed to follow a normal distribution.

In contrast to ordered-response models, Multinomial-Logit and Probit models neglect the data's ordinality, require estimation of more parameters (in the case of three or more alternatives, thus reducing the degrees of freedom available for estimation), and are associated with undesirable properties, such as the independence of irrelevant alternatives (in the case of the Multinomial-Logit) or lack of closed-form likelihood function (in the case of a Multinomial-Probit) (Greene, 2003).

The following specification is used here:

$$MT_n^* = \phi' z_n + \varepsilon_n$$

where MT_n^*= latent and continues measure of maize type (MT) used by farmer n in a plot.

z_n= a vector of explanatory variables describing the farm household, plot and, government programs characteristics ($\Psi_{HH}, \Psi_{Farm}, \Psi_{Gprogram}$, respectively).

ϕ= a vector of parameters to be estimated, and

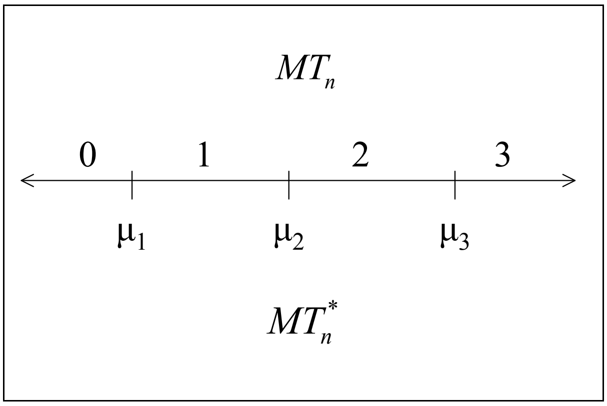
ε_n = a random error term (assumed to follow a standard normal distribution).

The observed and discrete maize type variable MT_n^* is determined from the model as follows, the model is adopted from: (Kockelman and Kweon, 2002):

$$MT_n \begin{cases} 0 = if & -\infty \leq MT_n^* \leq \mu_1 (Maize - Landrace) \\ 1 = if & \mu_1 < MT_n^* \leq \mu_2 (Maize - Creolized) \\ 2 = if & \mu_2 < MT_n^* \leq \mu_3 (Different - Germplasm) \\ 3 = if & \mu_3 < MT_n^* \leq \infty (Maize - Hybrid + OPV) \end{cases}$$

where μ_i's represent thresholds to be estimated (along with the parameter vector ϕ). Figure A.1 illustrates the correspondence between the latent, continuous underlying Maize Type variable (MT_n^*), and the observed Maize Type class (MT_n).

Figure A.1: Relationship between latent and coded maize type variables



Source: adopted from Kockelman and Kweon (2002)

The probabilities associated with the coded response of an Ordered-Probit model are as follows:

$$P_n(0) = \Pr(MT_n = 0) = \Pr(MT_n^* \le \mu_1) = \Pr(\phi' z_n + \varepsilon_n \le \mu_1) = \Pr(\varepsilon_n \le \mu_1 - \phi' z_n) = \Phi(\mu_1 - \phi' z_n)$$

$$P_n(1) = \Pr(MT_n = 1) = \Pr(\mu_1 < MT_n^* \le \mu_2) = \Pr(\varepsilon_n \le \mu_2 - \phi' z_n) - \Pr(\varepsilon_n \le \mu_1 - \phi' z_n)$$

$$= \Phi(\mu_2 - \phi' z_n) - \Phi(\mu_1 - \phi' z_n)$$

$$\vdots$$

$$P_n(k) = \Pr(MT_n = k) = \Pr(\mu_k < MT_n^* \le \mu_{k+1}) = \Phi(\mu_{k+1} - \phi' z_n) - \Phi(\mu_k - \phi' z_n)$$

$$\vdots$$

$$P_n(K) = \Pr(MT_n = K) = \Pr(\mu_K < MT_n^*) = 1 - \Phi(\mu_K - \phi' z_n)$$

where *n* is an individual, *k* is response alternative, $P(MT_n = k)$ is the probability that individual *n* responds in manner *k*, and $\Phi(\cdot)$ is the standard normal cumulative distribution function.

The interpretation of this model's parameters set, ϕ, is as follows: positive signs indicate higher farmer preference for improved germplasm (e.g., hybrid or OPVs) as the value of the associated variables increase, while negative signs suggest the converse. These interactions must be compared to the ranges between the various thresholds, μ_i, in order to determine the most likely maize improved germplasm use classification for a particular farmer.

Tables A.6 to A.9 present the econometric results for Ordered-Probit model for Chiapas and Oaxaca. Each table is followed by a brief economic interpretation.

Dependent variable: 0) maize landrace, 1) maize creolized, 2) use different maize types, and 3) use maize hybrid, OPV or both.

Table A.6: Parameters for Ordered-Probit model for farmer's maize type use in Chiapas

Variable	Coefficient	T-Ratio	Sig
Constant	1.685	2.699	***
Households characteristics			
AGE	-0.002	-0.234	
EDUDUMMY	0.329	1.368	
HHSIZE	-0.074	-1.580	
SHAM1550	0.008	1.083	
STAPLEC	-0.091	-1.025	
HORSE	0.187	1.678	*
REMITTAN	0.075	0.246	
DISTANCE	-0.017	-2.885	***
Farm characteristics			
LANDOWNER	0.641	1.614	
NUMPLOTS	-0.400	-3.247	***
AREAMAIZ	0.113	2.903	***
ARED	0.021	0.341	
SLOPE	-0.086	-0.447	
Government programs			
SUBSIDY	-0.587	-1.739	*
SEEDX	0.136	0.648	
ACCESEXT	-0.056	-0.457	
Mu(1)	0.489	5.965	***
Mu(2)	1.264	11.347	***
Chi-square: 32.16879; p-value: 0.009506			

According to Table A.6 (above) five of the sixteen variables are statistically significant and have the expected coefficient sign for Chiapas. Since the dependent variable, or improved germplasm index, increases with the use of high yield varieties, positive coefficients suggest the likelihood of using hybrid or OPV varieties. Thus, increases in the number horses and farm size are associated with use of hybrid and OPV varieties, while distance, number of plots and subsidy are associated with decreased use of modern varieties.

Table A.7 (below) presents the summary of marginal effects as a breakdown by maize type selection. The results confirm and support the previous findings. Thus, the number of horses and the area planted with maize (proxy of farm size) have positive signed coefficients for choosing maize hybrid and OPV. The coefficients for distance, number of plots and subsidy variables have negative signs for choice of high yielding varieties, and positive sign for the other varieties. Unfortunately, key variables like age and education are not significant, although have the expected coefficient sign.

Table A.7: Summary of marginal effects for Ordered-Probit model for Chiapas

Variable:	Y=0	Y=1	Y=2	Y=3
Constant	0.0000	0.0000	0.0000	0.0000
Households characteristics				
AGE	0.0004	0.0002	0.0000	-0.0006
(d)EDUDUMM	-0.0896	-0.0318	0.0005	0.1209
HHSIZE	0.0188	0.0078	0.0016	-0.0282
SHAM1550	-0.0019	-0.0008	-0.0002	0.0029
STAPLEC	0.0230	0.0095	0.0020	-0.0345
HORSE	-0.0472	-0.0196	-0.0041	0.0710
(d)REMITTAN	-0.0184	-0.0080	-0.0022	0.0286
DISTANCE	0.0042	0.0018	0.0004	-0.0064
Farm characteristics				
(d)LANDOWNER	-0.1986	-0.0474	0.0309	0.2151
NUMPLOTS	0.1011	0.0420	0.0089	-0.1519
AREAMAIZ	-0.0286	-0.0119	-0.0025	0.0429
ARED	-0.0053	-0.0022	-0.0005	0.0080
(d)SLOPE	0.0219	0.0090	0.0018	-0.0327
Government programs				
(d)SUBSIDY	0.1209	0.0653	0.0432	-0.2294
(d)SEEDX	-0.0337	-0.0144	-0.0037	0.0519
ACCESEXT	0.0142	0.0059	0.0013	-0.0214

Marginal effects (ME) for ordered probability model
ME for dummy variables are Pr[y|x=1]-Pr[y|x=0]
(d) Dummy variable

According to Table A.8 (below) four of the eighteen variables are statistically significant and have the expected coefficient sign for Oaxaca, i.e., ethnicity, proportion of male family members aged between 15 to 50 years, remittances and good soil quality are associated with increased likelihood of selecting improved germplasm.

Table A.8: Parameters for Ordered-Probit model
for farmers' maize type use in Oaxaca

Variable	Coefficient	T-Ratio	Sig.
Constant	-1.872	-2.123	*
Households characteristics			
AGE	0.002	0.250	
EDUDUMMY	0.202	0.724	
ETHNICTY	0.586	2.457	**
HHSIZE	-0.024	-0.490	
SHAM1550	0.018	2.382	**
STAPLEC	-0.037	-0.296	
HORSE	0.129	1.505	
REMITTAN	0.876	1.817	*
DISTANCE	-0.007	-1.253	
Farm characteristics			
LANDOWNER	0.111	0.357	
NUMPLOTS	0.002	0.008	
AREAMAIZ	0.054	0.690	
REDSOIL	0.180	0.619	
SLOPE	0.350	1.327	
GOOD	0.533	2.315	**
Government programs			
SUBSIDY	0.138	0.528	
SEEDX	-0.271	-0.952	
ACCEXTEN	0.130	0.500	
Mu(1)	0.733	6.412	***
Mu(2)	1.464	7.816	***

Chi-square: 31.92959; *p*-value: .02241300

Finally, Table A.9 (below) presents the summary of marginal effects (by maize type selection). All the statistically significant variables from Table A.8 have the expected coefficient signs (i.e., ethnicity, share of male family members, remittances, and good soil quality). The positive sign of these variables suggests an increase in the likelihood of improved germplasm selection. The results are in agreement with adoption theory. But unfortunately, key variables like age, education, farm and government program characteristics are weak and are not statistically significant, and some of them have unexpected coefficient sign.

Table A.9: Summary of marginal effects for Ordered-Probit model for Oaxaca

Variable:	Y=0	Y=1	Y=2	Y=3
Constant	0.0000	0.0000	0.0000	0.0000
Households characteristics				
AGE	-0.0008	0.0004	0.0003	0.0001
(d)EDUDUMM	-0.0664	0.0341	0.0231	0.0092
(d)ETHNICT	-0.1962	0.096	0.0697	0.0305
HHSIZE	0.0082	-0.0041	-0.0029	-0.0012
SHAM1550	-0.0063	0.0031	0.0022	0.0009
STAPLEC	0.0124	-0.0062	-0.0044	-0.0018
HORSE	-0.0438	0.0218	0.0155	0.0065
(d)REMITTAN	-0.3341	0.1032	0.1342	0.0966
DISTANCE	0.0025	-0.0012	-0.0009	-0.0004
Farm characteristics				
(d)LANDOWNER	-0.0369	0.0188	0.0129	0.0052
NUMPLOTS	-0.0007	0.0004	0.0003	0.0001
AREAMAIZ	-0.0184	0.0091	0.0065	0.0027
(d)REDSOIL	-0.0629	0.0297	0.0229	0.0103
(d)SLOPE	-0.1126	0.0588	0.0386	0.0152
(d)GOOD	-0.1727	0.0884	0.0598	0.0244
Government programs				
(d)SUBSIDY	-0.046	0.0234	0.0161	0.0065
(d)SEEDX	0.088	-0.0457	-0.0304	-0.012
(d)ACCEXTE	-0.0449	0.0217	0.0161	0.007

Marginal effects (ME) for ordered probability model
ME for dummy variables are Pr[y|x=1]-Pr[y|x=0]
(d) Dummy variable

A.3 Propensity score matching results

Tables from A.10 to A.13 show the outcome for per-capita expenditure (PCE).

Table A.10: Effects of all improved maize varieties adoption on PCE for Chiapas

Matching Algorithm	Common-Support			Off	Bootstrap 50 replications*		
	Effect	SE	*t*	Supp	Coeff.	Bootstrap	*z*
NNM w/o replacement	94.701	57.315	1.65	98	133.682	47.241	2.83
Caliper 0.01	88.889	75.166	1.18	111	133.682	52.455	2.55
Caliper 0.02	157.593	74.874	2.10	108	133.682	55.069	2.43
Caliper 0.05	189.378	81.183	2.33	105	133.682	53.265	2.51
NNM w/ replacement	146.157	59.713	2.45	11	133.682	61.829	2.16
Caliper 0.01	100.337	62.578	1.60	59	133.682	48.261	2.77
Caliper 0.02	124.011	60.946	2.03	35	133.682	69.896	1.91
Caliper 0.05	146.157	59.713	2.45	11	133.682	69.152	1.93
NNM Oversampling							
2 NNM	144.592	54.593	2.65	11	133.682	55.692	2.40
5 NNM	111.645	50.275	2.22	11	133.682	60.767	2.20
10 NNM	63.292	49.329	1.28	11	133.682	55.104	2.43
KBM Epanechnikov							
Bandwidth 0.06	117.478	50.307	2.34	11	133.682	64.314	2.08
Bandwidth 0.03	142.359	54.649	2.60	15	133.682	46.823	2.86
Bandwidth 0.01	102.945	60.214	1.71	59	133.682	70.065	1.91

*Common-Support allowed

Table A.11: Effects of all improved maize varieties adoption on PCE for Oaxaca

Matching Algorithm	Common-Support			Off	Bootstrap 100 replications*		
	Effect	SE	*t*	Supp	Coeff.	Bootstrap	*z*
NNM w/o replacement	116.827	77.770	1.50	2	181.072	88.780	2.04
Caliper 0.01	88.335	100.284	0.88	20	181.072	105.705	1.71
Caliper 0.02	128.696	101.245	1.27	18	181.072	100.117	1.81
Caliper 0.05	21.877	88.992	0.25	13	181.072	89.389	2.03
NNM w/ replacement	173.938	98.640	1.76	2	181.072	85.914	2.11
Caliper 0.01	128.850	100.106	1.29	12	181.072	89.063	2.03
Caliper 0.02	170.835	102.765	1.66	5	181.072	96.823	1.87
Caliper 0.05	173.938	98.640	1.76	2	181.072	114.888	1.58
NNM Oversampling							
2 NNM	135.500	85.987	1.58	2	181.072	104.912	1.73
5 NNM	153.641	73.461	2.09	2	181.072	82.808	2.19
10 NNM	155.673	70.655	2.20	2	181.072	101.615	1.78
KBM Epanechnikov							
Bandwidth 0.06	137.875	70.920	1.94	2	181.072	110.094	1.64
Bandwidth 0.03	182.710	74.235	2.46	2	181.072	93.300	1.94
Bandwidth 0.01	142.493	79.448	1.79	12	181.072	101.928	1.78

*Common-Support allowed

Table A.12: Effects of Maize Hybrid adoption on PCE for Chiapas

Matching Algorithm	Common-Support			Off	Bootstrap 50 replications*		
	Effect	SE	*t*	Supp	Coeff.	Bootstrap	*z*
NNM w/o replacement	87.445	50.853	1.72	9	141.000	57.748	2.44
Caliper 0.01	101.927	57.537	1.77	29	141.000	51.691	2.73
Caliper 0.02	120.202	57.428	2.09	24	141.000	65.949	2.14
Caliper 0.05	122.284	57.461	2.13	21	141.000	54.527	2.59
NNM with replacement	118.851	52.883	2.25	9	141.000	54.283	2.60
Caliper 0.01	110.677	53.399	2.07	13	141.000	48.835	2.89
Caliper 0.02	104.764	51.890	2.02	10	141.000	57.812	2.44
Caliper 0.05	118.851	52.883	2.25	9	141.000	53.495	2.64
NNM Oversampling							
2 NNM	101.696	52.344	1.94	9	141.000	73.499	1.92
5 NNM	73.475	52.155	1.41	9	141.000	55.015	2.56
10 NNM	81.439	51.617	1.58	9	141.000	68.890	2.05
KBM Epanechnikov							
Bandwidth 0.06	88.545	51.524	1.72	9	141.000	56.877	2.48
Bandwidth 0.03	90.632	52.372	1.73	9	141.000	56.326	2.50
Bandwidth 0.01	100.106	54.932	1.82	13	141.000	66.843	2.11

*Common-Support allowed

Table A.13: Effects of Creolized Maize adoption on PCE for Oaxaca

Matching Algorithm	Common-Support			Off	Bootstrap 100 replications*		
	Effect	SE	*t*	Supp	Coeff.	Bootstrap	*z*
NNM w/o replacement	165.739	90.253	1.84	1	218.444	122.170	1.79
Caliper 0.01	128.923	75.028	1.72	9	218.444	123.326	1.77
Caliper 0.02	140.775	90.151	1.56	6	218.444	118.230	1.85
Caliper 0.05	155.668	91.476	1.70	2	218.444	112.641	1.94
NNM with replacement	189.017	90.737	2.08	1	218.444	119.034	1.84
Caliper 0.01	203.787	83.225	2.45	8	218.444	111.994	1.95
Caliper 0.02	167.261	96.698	1.73	4	218.444	99.520	2.19
Caliper 0.05	189.017	90.737	2.08	1	218.444	104.536	2.09
NNM Oversampling							
2 NNM	148.845	88.414	1.68	1	218.444	110.163	1.98
5 NNM	154.194	81.887	1.88	1	218.444	106.091	2.06
10 NNM	177.589	80.719	2.20	1	218.444	124.459	1.76
KBM Epanechnikov							
Bandwidth 0.06	160.040	88.332	1.81	1	218.444	114.087	1.91
Bandwidth 0.03	170.130	83.944	2.03	2	218.444	122.395	1.78
Bandwidth 0.01	171.403	87.772	1.95	8	218.444	106.600	2.05

*Common-Support allowed

Tables A.14 to A.17 show the outcome for food poverty as dichotomy variable.

Table A.14: Effects for all improved maize varieties adoption on poverty for Chiapas

Matching Algorithm	Common-Support			Off	Bootstrap 50 replications*		
	Effect	SE	*t*	Supp	Coeff.	Bootstrap	*z*
NNM w/o replacement	-0.063	0.127	-0.49	98	-0.169	0.162	-1.05
Caliper 0.01	-0.158	0.165	-0.96	111	-0.169	0.167	-1.02
Caliper 0.02	-0.182	0.151	-1.20	108	-0.169	0.167	-1.02
Caliper 0.05	-0.240	0.140	-1.71	105	-0.169	0.159	-1.07
NNM w/ replacement	-0.185	0.146	-1.26	11	-0.169	0.145	-1.16
Caliper 0.01	-0.183	0.153	-1.20	59	-0.169	0.190	-0.89
Caliper 0.02	-0.158	0.144	-1.10	35	-0.169	0.184	-0.92
Caliper 0.05	-0.185	0.146	-1.26	11	-0.169	0.185	-0.92
NNM Oversampling							
2 NNM	-0.239	0.139	-1.72	11	-0.169	0.169	-1.00
5 NNM	-0.143	0.131	-1.09	11	-0.169	0.168	-1.00
10 NNM	-0.071	0.128	-0.56	11	-0.169	0.188	-0.90
KBM Epanechnikov							
Bandwidth 0.06	-0.146	0.129	-1.14	11	-0.169	0.164	-1.03
Bandwidth 0.03	-0.224	0.141	-1.58	15	-0.169	0.189	-0.90
Bandwidth 0.01	-0.172	0.150	-1.15	59	-0.169	0.183	-0.92

*Common-Support allowed

Table A.15: Effects for all improved maize varieties adoption on poverty for Oaxaca

Matching Algorithm	Common-Support			Off	Bootstrap 100 replications*		
	Effect	SE	*t*	Supp	Coeff.	Bootstrap	*z*
NNM w/o replacement	-0.140	0.098	-1.44	2	-0.135	0.143	-0.94
Caliper 0.01	-0.156	0.122	-1.28	20	-0.135	0.148	-0.91
Caliper 0.02	-0.176	0.118	-1.50	18	-0.135	0.135	-1.00
Caliper 0.05	-0.051	0.110	-0.47	13	-0.135	0.139	-0.97
NNM w/ replacement	-0.240	0.129	-1.86	2	-0.135	0.121	-1.11
Caliper 0.01	-0.225	0.129	-1.74	12	-0.135	0.129	-1.05
Caliper 0.02	-0.277	0.132	-2.10	5	-0.135	0.134	-1.01
Caliper 0.05	-0.240	0.129	-1.86	2	-0.135	0.145	-0.93
NNM Oversampling							
2 NNM	-0.150	0.115	-1.31	2	-0.135	0.148	-0.91
5 NNM	-0.176	0.099	-1.78	2	-0.135	0.147	-0.92
10 NNM	-0.172	0.095	-1.81	2	-0.135	0.135	-1.00
KBM Epanechnikov							
Bandwidth 0.06	-0.143	0.096	-1.49	2	-0.135	0.138	-0.98
Bandwidth 0.03	-0.183	0.110	-1.66	2	-0.135	0.140	-0.96
Bandwidth 0.01	-0.177	0.119	-1.49	12	-0.135	0.137	-0.98

*Common-Support allowed

Table A.16: Effects for Maize Hybrid adoption on poverty for Chiapas

Matching Algorithm	Common-Support			Off	Bootstrap 50 replications*		
	Effect	SE	*t*	Supp	Coeff.	Bootstrap	*z*
NNM w/o replacement	-0.059	0.086	-0.68	9	-0.078	0.126	-0.62
Caliper 0.01	-0.063	0.103	-0.61	29	-0.078	0.130	-0.60
Caliper 0.02	-0.075	0.097	-0.78	24	-0.078	0.149	-0.52
Caliper 0.05	-0.071	0.095	-0.75	21	-0.078	0.134	-0.58
NNM with replacement	-0.074	0.113	-0.65	9	-0.078	0.129	-0.60
Caliper 0.01	-0.047	0.115	-0.41	13	-0.078	0.135	-0.58
Caliper 0.02	-0.060	0.113	-0.53	10	-0.078	0.118	-0.66
Caliper 0.05	-0.074	0.113	-0.65	9	-0.078	0.139	-0.56
NNM Oversampling							
2 NNM	-0.037	0.097	-0.38	9	-0.078	0.115	-0.68
5 NNM	-0.006	0.091	-0.06	9	-0.078	0.132	-0.59
10 NNM	-0.026	0.089	-0.30	9	-0.078	0.136	-0.57
KBM Epanechnikov							
Bandwidth 0.06	-0.034	0.089	-0.38	9	-0.078	0.144	-0.54
Bandwidth 0.03	-0.033	0.092	-0.36	9	-0.078	0.141	-0.55
Bandwidth 0.01	-0.023	0.099	-0.23	13	-0.078	0.139	-0.56

*Common-Support allowed

Table A.17: Effects for Maize Creolized adoption on poverty for Oaxaca

Matching Algorithm	Common-Support			Off	Bootstrap 100 replications*		
	Effect	SE	*t*	Supp	Coeff.	Bootstrap	*z*
NNM w/o replacement	-0.184	0.113	-1.63	1	-0.128	0.159	-0.81
Caliper 0.01	-0.133	0.125	-1.06	9	-0.128	0.174	-0.74
Caliper 0.02	-0.152	0.121	-1.25	6	-0.128	0.173	-0.74
Caliper 0.05	-0.189	0.114	-1.66	2	-0.128	0.151	-0.85
NNM with replacement	-0.211	0.120	-1.75	1	-0.128	0.158	-0.81
Caliper 0.01	-0.194	0.128	-1.51	8	-0.128	0.144	-0.89
Caliper 0.02	-0.171	0.126	-1.36	4	-0.128	0.153	-0.84
Caliper 0.05	-0.211	0.120	-1.75	1	-0.128	0.156	-0.82
NNM Oversampling							
2 NNM	-0.118	0.113	-1.04	1	-0.128	0.154	-0.83
5 NNM	-0.163	0.104	-1.57	1	-0.128	0.146	-0.88
10 NNM	-0.197	0.101	-1.95	1	-0.128	0.155	-0.82
KBM Epanechnikov							
Bandwidth 0.06	-0.190	0.100	-1.90	1	-0.128	0.147	-0.87
Bandwidth 0.03	-0.186	0.102	-1.83	2	-0.128	0.168	-0.76
Bandwidth 0.01	-0.157	0.115	-1.36	8	-0.128	0.153	-0.84

*Common-Support allowed

Table A.18: PSM quality indicators for Chiapas

Matching Algorithm	Sample	All maize types adoption				Maize hybrid adoption			
		Pseudo R^2	LR chi^2 **1/**	p> chi^2	Mean of SB **2/**	Pseudo R^2	LR chi^2	p>chi^2	Mean of SB
NNM **3/**	BM **4/**	0.166	26.80	0.005	19.619	0.118	26.55	0.005	17.911
	AM **5/**	0.069	6.09	0.867	13.777	0.020	3.81	0.975	8.061
0.01 **6/**	BM	0.166	26.80	0.005	19.619	0.118	26.55	0.005	17.911
	AM	0.113	5.60	0.847	12.800	0.033	4.38	0.957	7.799
0.02 **6/**	BM	0.166	26.80	0.005	19.619	0.118	26.55	0.005	17.911
	AM	0.097	5.76	0.835	18.846	0.032	4.69	0.945	7.739
0.05 **6/**	BM	0.166	26.80	0.005	19.619	0.118	26.55	0.005	17.911
	AM	0.133	8.63	0.567	12.838	0.034	5.25	0.918	8.699
NNM **7/**	BM	0.166	26.80	0.005	19.619	0.118	26.55	0.005	17.911
	AM	0.100	31.69	0.000	21.131	0.020	3.76	0.977	5.681
0.01 **6/**	BM	0.166	26.80	0.005	19.619	0.118	26.55	0.005	17.911
	AM	0.121	22.50	0.013	19.993	0.023	4.16	0.965	6.997
0.02 **6/**	BM	0.166	26.80	0.005	19.619	0.118	26.55	0.005	17.911
	AM	0.080	20.09	0.028	14.591	0.020	3.78	0.976	5.544
0.05 **6/**	BM	0.166	26.80	0.005	19.619	0.118	26.55	0.005	17.911
	AM	0.100	31.69	0.000	21.131	0.020	3.76	0.977	5.681
NNM **8/**									
2 NN	BM	0.166	26.80	0.005	19.619	0.118	26.55	0.005	17.911
	AM	0.095	31.50	0.001	14.800	0.012	2.17	0.998	4.473
5 NN	BM	0.166	26.80	0.005	19.619	0.118	26.55	0.005	17.911
	AM	0.045	14.85	0.189	14.750	0.005	0.96	1.000	4.520
10 NN	BM	0.166	26.80	0.005	19.619	0.118	26.55	0.005	17.911
	AM	0.050	16.50	0.124	19.382	0.006	1.09	1.000	5.363
KBM									
0.06 **9/**	BM	0.166	26.80	0.005	19.619	0.118	26.55	0.005	17.911
	AM	0.048	15.91	0.144	15.423	0.004	0.73	1.000	4.185
0.03 **9/**	BM	0.166	26.80	0.005	19.619	0.118	26.55	0.005	17.911
	AM	0.076	24.21	0.012	15.475	0.002	0.37	1.000	3.108
0.01 **9/**	BM	0.166	26.80	0.005	19.619	0.118	26.55	0.005	17.911
	AM	0.130	24.11	0.007	20.626	0.008	1.46	1.000	4.365

1/ Log-likelihood Ratio; **2/** Mean of Standardised bias (has been calculated as an unweighted average of all covariates; **3/** Matching without replacement; **4/** Before Match; **5/** After Match; **6/** Caliper; **7/** Matching wit replacement; **8/** Oversampling; **9/** Bandwidth.

Table A.19: PSM quality indicators for Oaxaca

Matching Algorithm	Sample	All maize types adoption				Creolized maize adoption			
		Pseudo R^2	LR chi^2 **1/**	p> chi^2	Mean of SB **2/**	Pseudo R^2	LR chi^2	p>chi^2	Mean of SB
NNM **3/**	BM **4/**	0.117	23.92	0.021	20.166	0.109	19.56	0.076	18.904
	AM **5/**	0.020	2.79	0.997	8.667	0.050	5.30	0.947	12.940
0.01 **6/**	BM	0.117	23.92	0.021	20.166	0.109	19.56	0.076	18.904
	AM	0.038	3.35	0.993	11.242	0.068	5.67	0.932	11.243
0.02 **6/**	BM	0.117	23.92	0.021	20.166	0.109	19.56	0.076	18.904
	AM	0.043	4.10	0.982	10.489	0.066	6.02	0.915	11.368
0.05 **6/**	BM	0.117	23.92	0.021	20.166	0.109	19.56	0.076	18.904
	AM	0.044	4.74	0.966	10.646	0.052	5.36	0.945	12.836
NNM **7/**	BM	0.117	23.92	0.021	20.166	0.109	19.56	0.076	18.904
	AM	0.040	5.78	0.927	9.740	0.054	5.72	0.930	13.655
0.01 **6/**	BM	0.117	23.92	0.021	20.166	0.109	19.56	0.076	18.904
	AM	0.039	4.32	0.977	10.808	0.095	8.16	0.772	16.326
0.02 **6/**	BM	0.117	23.92	0.021	20.166	0.109	19.56	0.076	18.904
	AM	0.043	5.66	0.932	9.442	0.076	7.38	0.832	14.549
0.05 **6/**	BM	0.117	23.92	0.021	20.166	0.109	19.56	0.076	18.904
	AM	0.034	4.75	0.966	7.454	0.054	5.72	0.930	13.655
NNM **8/**									
2 NN	BM	0.117	23.92	0.021	20.166	0.109	19.56	0.076	18.904
	AM	0.030	4.13	0.981	7.297	0.032	3.33	0.993	9.118
5 NN	BM	0.117	23.92	0.021	20.166	0.109	19.56	0.076	18.904
	AM	0.015	2.06	0.999	5.639	0.029	3.11	0.995	7.233
10 NN	BM	0.117	23.92	0.021	20.166	0.109	19.56	0.076	18.904
	AM	0.014	1.99	0.999	4.145	0.027	2.85	0.997	6.244
KBM									
0.06 **9/**	BM	0.117	23.92	0.021	20.166	0.109	19.56	0.076	18.904
	AM	0.011	1.50	1.000	3.891	0.014	1.51	1.000	4.043
0.03 **9/**	BM	0.117	23.92	0.021	20.166	0.109	19.56	0.076	18.904
	AM	0.026	3.67	0.989	6.038	0.019	1.99	0.999	5.098
0.01 **9/**	BM	0.117	23.92	0.021	20.166	0.109	19.56	0.076	18.904
	AM	0.019	2.09	0.999	6.700	0.056	4.83	0.963	8.373

1/ Log-likelihood Ratio; **2/** Mean of Standardised bias (has been calculated as an unweighted average of all covariates; **3/** Matching without replacement; **4/** Before Match; **5/** After Match; **6/** Caliper; **7/** Matching wit replacement; **8/** Oversampling; **9/** Bandwidth.

Table A.20: Sensitivity Analysis for all improved maize varieties adoption for Chiapas

Matching Algorithm	ATT*	Critical value of gamma. Upper Bounds reported								
		1	1.05	1.1	1.15	1.2	1.4	1.6	1.8	2
NNM w/o replacement	94.701	46.40	39.30	36.30	26.66	22.96	3.60	-10.65	-19.42	-30.35
(p-value)		0.17491	0.20760	0.24176	0.27693	0.31271	0.45470	0.58313	0.69011	0.77447
Caliper 0.01	88.889	**77.60**	65.89	63.04	58.31	55.71	45.97	29.26	18.78	3.38
(p-value)		0.09209	0.10839	0.12564	0.14370	0.16243	0.24177	0.32343	0.40286	0.47731
Caliper 0.02	157.593	**125.99**	**114.84**	**106.91**	**105.36**	**101.17**	**84.40**	**74.38**	60.21	50.18
(p-value)		0.00929	0.01209	0.01536	0.01912	0.02337	0.04523	0.07423	0.10903	0.14812
Caliper 0.05	189.378	**136.91**	**130.28**	**123.12**	**117.35**	**112.67**	**87.77**	70.80	51.66	45.23
(p-value)		0.01233	0.01615	0.02063	0.02580	0.03166	0.06184	0.10168	0.14897	0.20126
NNM w/ replacement	146.157	**97.91**	**91.47**	**86.17**	**80.81**	**75.79**	**57.72**	**43.48**	**30.65**	19.89
(p-value)		0.00004	0.00010	0.00024	0.00050	0.00098	0.00822	0.03536	0.09813	0.20176
Caliper 0.01	100.337	**65.93**	**62.24**	**56.28**	**51.84**	**48.76**	32.94	19.49	8.22	-0.75
(p-value)		0.00871	0.01391	0.02110	0.03063	0.04278	0.12023	0.23975	0.38281	0.52665
Caliper 0.02	124.011	**75.79**	**69.67**	**65.19**	**60.01**	**55.35**	**38.82**	24.42	12.14	0.41
(p-value)		0.00237	0.00441	0.00767	0.01255	0.01951	0.07575	0.18515	0.33564	0.49843
Caliper 0.05	146.157	**97.91**	**91.47**	**86.17**	**80.81**	**75.79**	**57.72**	**43.48**	**30.65**	19.89
(p-value)		0.00004	0.00010	0.00024	0.00050	0.00098	0.00822	0.03536	0.09813	0.20176
NNM Oversampling										
2 NNM	144.592	**93.57**	**87.39**	**82.58**	**77.17**	**72.18**	**56.56**	**44.62**	**31.95**	22.17
(p-value)		0.00002	0.00005	0.00011	0.00025	0.00051	0.00480	0.02271	0.06828	0.15032
5 NNM	111.645	**59.20**	**53.24**	**48.21**	**42.98**	**38.85**	21.32	7.91	-5.20	-14.04
(p-value)		0.00620	0.01159	0.02008	0.03254	0.04980	0.17466	0.37269	0.58436	0.75639
10 NNM	63.292	-1.26	-7.04	-12.65	-16.70	-21.41	-37.17	-49.50	-59.19	-68.33
(p-value)		0.52221	0.61282	0.69395	0.76360	0.82125	0.95121	0.98935	0.99802	0.99967
KBM Epanechnikov										
Bandwidth 0.06	117.478	**61.38**	**56.76**	**51.74**	**47.43**	**42.56**	27.40	13.56	1.52	-9.40
(p-value)		0.00264	0.00524	0.00960	0.01640	0.02637	0.10952	0.26704	0.46472	0.65105
Bandwidth 0.03	142.359	**90.29**	**84.90**	**78.93**	**73.72**	**68.66**	**53.44**	**39.46**	27.61	16.40
(p-value)		0.00006	0.00014	0.00031	0.00063	0.00122	0.00947	0.03878	0.10411	0.20924
Bandwidth 0.01	102.945	**64.31**	**59.49**	**55.59**	**51.52**	**48.18**	32.71	19.95	9.89	0.96
(p-value)		0.00676	0.01096	0.01687	0.02480	0.03504	0.10261	0.21147	0.34688	0.48788

*Common-Support allowed

Table A.21: Sensitivity Analysis for maize hybrid adoption for Chiapas

Matching Algorithm	ATT*	Critical value of gamma. Upper Bounds reported								
		1	1.05	1.1	1.15	1.2	1.4	1.6	1.8	2
NNM w/o replacement	87.445	**49.78**	**44.58**	38.85	35.25	29.00	12.36	-3.92	-16.26	-29.15
(p-value)		0.05817	0.08136	0.10926	0.14165	0.17811	0.35156	0.53426	0.69085	0.80743
Caliper 0.01	101.927	**53.63**	48.83	41.20	35.63	29.68	10.71	-3.38	-17.16	-27.38
(p-value)		0.09812	0.12599	0.15714	0.19114	0.22748	0.38543	0.54069	0.67347	0.77682
Caliper 0.02	120.202	**69.92**	**63.45**	**57.53**	**51.78**	**47.09**	26.57	13.26	1.51	-9.49
(p-value)		0.03120	0.04368	0.05895	0.07707	0.09800	0.20632	0.33983	0.47764	0.60369
Caliper 0.05	122.284	**78.72**	**72.54**	**63.33**	**57.09**	51.73	31.43	12.59	-1.65	-13.95
(p-value)		0.03384	0.04757	0.06439	0.08435	0.10738	0.22578	0.36917	0.51358	0.64184
NNM w/ replacement	118.851	**51.66**	44.97	38.01	30.73	25.03	7.35	-6.82	-23.33	-33.02
(p-value)		0.07727	0.10578	0.13926	0.17725	0.21907	0.40812	0.59356	0.74257	0.84708
Caliper 0.01	110.677	**48.27**	42.60	36.19	27.22	22.98	5.87	-9.87	-26.25	-34.69
(p-value)		0.08944	0.12002	0.15526	0.19460	0.23734	0.42558	0.60567	0.74887	0.84925
Caliper 0.02	104.764	44.24	36.81	28.36	23.97	19.06	1.49	-12.75	-28.08	-36.93
(p-value)		0.10692	0.14234	0.18265	0.22708	0.27467	0.47685	0.65906	0.79506	0.88435
Caliper 0.05	118.851	**51.66**	44.97	38.01	30.73	25.03	7.35	-6.82	-23.33	-33.02
(p-value)		0.07727	0.10578	0.13926	0.17725	0.21907	0.40812	0.59356	0.74257	0.84708
NNM Oversampling										
2 NNM	101.696	23.99	16.90	11.78	6.07	-1.72	-18.10	-34.16	-46.06	-56.85
(p-value)		0.26857	0.32908	0.39122	0.45328	0.51379	0.72093	0.85671	0.93227	0.96991
5 NNM	73.475	-3.18	-8.33	-14.89	-18.03	-24.43	-40.26	-54.48	-65.79	-79.63
(p-value)		0.55105	0.61914	0.68088	0.73562	0.78323	0.91015	0.96651	0.98842	0.99621
10 NNM	81.439	6.90	1.45	-3.39	-9.69	-12.99	-30.34	-44.13	-55.32	-64.36
(p-value)		0.42010	0.48930	0.55560	0.61758	0.67430	0.84304	0.93224	0.97298	0.98984
KBM Epanechnikov										
Bandwidth 0.06	88.545	6.73	1.12	-3.88	-10.64	-16.35	-32.48	-44.45	-56.15	-64.80
(p-value)		0.40582	0.47468	0.54107	0.60349	0.66093	0.83394	0.92717	0.97050	0.98874
Bandwidth 0.03	90.632	14.50	9.04	2.36	-3.70	-9.44	-25.98	-41.56	-53.27	-65.69
(p-value)		0.34337	0.40962	0.47526	0.53864	0.59845	0.78887	0.90068	0.95693	0.98241
Bandwidth 0.01	100.106	18.40	14.04	8.64	3.78	-2.05	-18.14	-32.54	-44.40	-52.99
(p-value)		0.28714	0.34744	0.40873	0.46943	0.52823	0.72771	0.85818	0.93155	0.96878

*Common-Support allowed

Table A.22: Sensitivity Analysis for all improved maize varieties adoption for Oaxaca

Matching Algorithm	ATT*	Critical value of gamma. Upper Bounds reported								
		1	1.05	1.1	1.15	1.2	1.4	1.6	1.8	2
NNM w/o replacement	116.83	**79.17**	**71.78**	62.52	54.48	49.13	23.90	3.35	-13.80	-29.02
(p-value)		0.07181	0.09463	0.12085	0.15018	0.18226	0.32888	0.48265	0.62121	0.73387
Caliper 0.01	88.33	49.72	36.11	30.38	23.76	17.18	-0.62	-16.95	-30.24	-42.81
(p-value)		0.21068	0.24703	0.28447	0.32248	0.36064	0.50757	0.63474	0.73655	0.81394
Caliper 0.02	128.70	62.49	56.64	45.13	35.35	30.38	9.24	-5.99	-17.92	-29.77
(p-value)		0.14264	0.17239	0.20404	0.23717	0.27137	0.41139	0.54305	0.65594	0.74694
Caliper 0.05	21.88	-3.34	-11.03	-15.19	-18.53	-24.71	-37.50	-52.03	-62.61	-73.65
(p-value)		0.52781	0.58027	0.62904	0.67385	0.71461	0.83909	0.91348	0.95500	0.97715
NNM w/ replacement	173.94	**119.55**	**107.87**	**99.24**	**92.93**	**88.18**	**60.82**	41.79	27.62	17.68
(p-value)		0.00519	0.00790	0.01153	0.01623	0.02212	0.05949	0.12010	0.20055	0.29368
Caliper 0.01	128.85	**87.87**	**77.60**	**71.78**	**67.01**	**60.59**	39.44	25.41	16.20	6.93
(p-value)		0.02120	0.02899	0.03843	0.04956	0.06239	0.12989	0.21802	0.31744	0.41904
Caliper 0.02	170.83	**117.62**	**106.83**	**99.24**	**93.45**	**88.61**	**63.74**	48.04	31.01	23.61
(p-value)		0.00491	0.00740	0.01071	0.01497	0.02028	0.05372	0.10783	0.18011	0.26482
Caliper 0.05	173.94	**119.55**	**107.87**	**99.24**	**92.93**	**88.18**	**60.82**	41.79	27.62	17.68
(p-value)		0.00519	0.00790	0.01153	0.01623	0.02212	0.05949	0.12010	0.20055	0.29368
NNM Oversampling										
2 NNM	135.50	**97.26**	**87.95**	**83.61**	**75.05**	**66.22**	46.42	28.09	10.45	-2.53
(p-value)		0.02207	0.03122	0.04257	0.05623	0.07224	0.15840	0.27126	0.39531	0.51633
5 NNM	153.64	**84.37**	**76.67**	**72.22**	**64.71**	59.25	36.39	17.32	-0.42	-12.08
(p-value)		0.04243	0.05780	0.07612	0.09733	0.12130	0.23968	0.37776	0.51464	0.63613
10 NNM	155.67	**82.46**	**75.18**	**69.04**	60.95	57.64	30.20	8.04	-7.36	-19.87
(p-value)		0.05506	0.07382	0.09577	0.12077	0.14859	0.28093	0.42764	0.56657	0.68482
KBM Epanechnikov										
Bandwidth 0.06	137.87	75.45	67.54	52.80	45.34	36.43	9.25	-8.86	-23.26	-35.30
(p-value)		0.10920	0.13985	0.17391	0.21087	0.25011	0.41760	0.57715	0.70899	0.80793
Bandwidth 0.03	182.71	**107.28**	**94.27**	**87.03**	**77.75**	**68.04**	42.43	21.92	6.30	-3.83
(p-value)		0.02530	0.03552	0.04809	0.06311	0.08059	0.17302	0.29134	0.41876	0.54078
Bandwidth 0.01	142.49	**89.16**	**80.67**	**71.52**	**65.60**	58.63	38.72	19.68	4.77	-9.87
(p-value)		0.04646	0.06103	0.07790	0.09700	0.11819	0.21992	0.33734	0.45612	0.56605

*Common-Support allowed

Table A.23: Sensitivity Analysis for maize creolized adoption for Oaxaca

Matching Algorithm	ATT*	Critical value of gamma. Upper Bounds reported								
		1	1.05	1.1	1.15	1.2	1.4	1.6	1.8	2
NNM w/o replacement	165.74	**104.74**	**100.42**	96.65	84.56	75.07	44.84	18.19	-5.00	-15.12
(p-value)		0.06668	0.08529	0.10628	0.12948	0.15464	0.26959	0.39424	0.51423	0.62082
Caliper 0.01	128.92	**96.20**	84.22	75.07	68.53	59.93	34.38	14.96	2.60	-12.14
(p-value)		0.08569	0.10537	0.12686	0.14994	0.17440	0.28134	0.39298	0.49939	0.59483
Caliper 0.02	140.77	**95.70**	84.22	73.30	59.93	50.88	29.00	8.81	-8.15	-25.57
(p-value)		0.09759	0.12029	0.14504	0.17155	0.19954	0.32039	0.44328	0.55666	0.65468
Caliper 0.05	155.67	**97.97**	92.03	77.68	67.90	58.53	28.83	6.97	-9.37	-28.12
(p-value)		0.09341	0.11681	0.14259	0.17045	0.20005	0.32909	0.46057	0.58064	0.68250
NNM w/ replacement	189.02	**134.82**	**129.64**	**121.76**	**112.38**	**104.61**	**82.35**	64.41	47.44	34.24
(p-value)		0.00853	0.01206	0.01650	0.02192	0.02839	0.06536	0.11951	0.18742	0.26413
Caliper 0.01	203.79	**131.10**	**122.92**	**112.38**	**104.30**	**98.39**	70.52	46.97	26.75	13.19
(p-value)		0.03570	0.04601	0.05783	0.07114	0.08586	0.15697	0.24188	0.33274	0.42309
Caliper 0.02	167.26	**103.74**	**98.39**	**91.25**	**82.18**	**76.62**	52.17	37.81	21.25	8.69
(p-value)		0.02981	0.03935	0.05053	0.06334	0.07774	0.14958	0.23818	0.33458	0.43104
Caliper 0.05	189.02	**134.82**	**129.64**	**121.76**	**112.38**	**104.61**	**82.35**	64.41	47.44	34.24
(p-value)		0.00853	0.01206	0.01650	0.02192	0.02839	0.06536	0.11951	0.18742	0.26413
NNM Oversampling										
2 NNM	148.84	**80.67**	**71.97**	69.34	64.47	55.41	25.99	14.74	-2.26	-10.94
(p-value)		0.06482	0.08305	0.10364	0.12644	0.15120	0.26475	0.38852	0.50819	0.61496
5 NNM	154.19	64.26	54.28	48.02	41.13	37.42	13.96	-3.07	-19.88	-30.09
(p-value)		0.12152	0.14994	0.18073	0.21345	0.24769	0.39136	0.52970	0.64941	0.74583
10 NNM	177.59	**85.04**	**78.09**	**69.48**	62.24	59.65	40.66	19.69	3.23	-8.44
(p-value)		0.05614	0.07251	0.09116	0.11197	0.13477	0.24124	0.36028	0.47802	0.58525
KBM Epanechnikov										
Bandwidth 0.06	160.04	65.71	60.51	50.08	43.79	34.60	9.80	-8.57	-22.44	-36.16
(p-value)		0.13678	0.16748	0.20045	0.23521	0.27127	0.41987	0.55924	0.67703	0.76985
Bandwidth 0.03	170.13	**92.20**	**88.28**	**75.55**	71.31	63.91	34.18	9.47	0.78	-12.84
(p-value)		0.06285	0.08041	0.10024	0.12219	0.14605	0.25571	0.37598	0.49327	0.59897
Bandwidth 0.01	171.40	**86.41**	**82.37**	76.32	69.82	66.38	40.25	24.56	10.51	-6.80
(p-value)		0.06820	0.08516	0.10395	0.12444	0.14643	0.24542	0.35271	0.45812	0.55511

*Common-Support allowed

A.4 Appendix concluding remarks

It was not possible to explain the maize type choice in Chiapas based on the results of a Multinomial-Logit model as only three independent variables; i.e., distance, number of plots, and area planted with maize, behaved as expected. For the rest of variables the results are weak economically and theoretically. In the same direction are the results for maize type choice for Oaxaca, where only four of the eighteen variables have the expected coefficient sign and significance level. Unexpected coefficient sign and significance level for key variables like age, education, and plot characteristics resulted.

Regarding the Ordered-Probit results, few variables are statistically significant. The major assumption is the consideration of the maize type as ordered class, where maize hybrid is ranked better than maize landraces. In reality, maize landraces and creolized varieties have attributes or traits that the farmers value more than maize hybrids or OPVs. Bellon et al., (2005) demonstrated that farmers do not perceive an overall superior maize type in both regions (Chiapas and Oaxaca) by asserting that all types have advantages and disadvantages. Their findings show that creolized varieties have attributes that lie between maize hybrids and maize landraces.

These results support the argument that Probit-model is suitable to analyze improved germplasm adoption decision when the dependent variable is binary, i.e., 1) if the farmer uses improved germplasm and 0) otherwise. Furthermore, given the interest to study the crop genetic conservation in maize crops, a Poisson model is appropriate to determine factors important in influencing the number of maize landraces that the farmers use, as well as the number of minor crops associated with local maize varieties, like beans and squash (pumpkin).

Appendix B

This appendix presents the questionnaire format applied in the 12 villages. The questionnaire comprises three sections, the first one correspond to male (farmer), the second one concern to female (farmer's spouse), and the last one for both male and female (couple). It is very important to take note that the original questionnaire was prepared and administered in Spanish. In the indigenous communities translators for local languages were employed.

SURVEY FOR FARMERS OF THE REGION COAST OF OAXACA AND FRAILESCA OF CHIAPAS, ON CREOLIZATION OF IMPROVED TUXPEÑO GERMPLASM

CIMMYT®

M

CIMMYT – Mexico 2001

SECTION A: IDENTIFICATION

Unique farmer registration code (UFRC): _____________ (A1). Enumerator name: ____________________________________ (A2).

Identification

Village name	Household address	M or F	Date	Survey number
A3	A4	A5	A6 / /	A7

Information about the respondents (**FARMER**)

Name	AH8
Age **(Years)**	AH9
Education **(Years in school)**	AH10
Mother tongue (a)	AH11
Read and write **(1=Yes, 0=No)**	AH12
Household position (e.g., head) (b)	AH13
From the village or immigrant (c)	AH14
1=Ejidatario 2=Settler	AH15

(a) 1=Spanish, 2=Mixteco, 3=Chatino, and 4=Other (specify) _____________
(b) 1=Husband, 2=Wife, 3=Son/Daughter, and 4=Other (specify) _________________
(c) 1=Community, 2=Immigrant, and 3=Other (specify) ______________________

1.- How long have you lived in this village? ______ **(Years)** AH16

SECTION C: HOUSEHOLD LIFE STRATEGY IN THE LAST FIVE YEARS

Activity (Continue…)	1=Yes 0=No	1=Priority 0=No Priority	1=Economic 2=Consumption 3=Other (specify)
Maize	CH101	CH101a	
Beans	CH102	CH102a	
Coffee	CH103	CH103a	
Squash	CH104	CH104a	
Sesame	CH105	CH105a	
Rice	CH106	CH106a	
Chili	CH107	CH107a	
Cacao	CH108	CH108a	
Groundnut	CH109	CH109a	
Tomato	CH110	CH110a	
Vegetables	CH111	CH111a	
Hibiscus	CH112	CH112a	
Fruit tree	CH113	CH113a	
Others (specify)	CH114	CH114a	
Cattle for meat	CH115	CH115a	
Dairy cattle for milk	CH116	CH116a	
Donkey	CH117	CH117a	
Mexican turkey cock	CH118	CH118a	

Activity (Conclude)	1=Yes 0=No	1=Priority 0=No Priority	1=Economic 2=Consumption 3=Other (specify)
Chicken	CH119	CH119a	
Pork	CH120	CH120a	
Goat	CH121	CH121a	
Shrimp	CH122	CH122a	
Fishing	CH123	CH123a	
Farming	CH124	CH124a	
Unskilled laborer	CH125	CH125a	
Commerce	CH126	CH126a	
Building worker	CH127	CH127a	
Carpenter	CH128	CH128a	
Driver	CH129	CH129a	
Skilled worker	CH130	CH130a	
Temporal migration (one season inside the community, and other season outside)	CH131	CH131a	
Permanent migration (Remittances by family members)	CH132	CH132a	
Handicrafts	CH133	CH133a	

1.- Comparing to 10 years ago, How is your family's welfare? **Better** ___ (CH135), **Equal** ___ (CH136), **Worse** ___ (CH137)

2.- Why? ____(CH138)

SECTION D: MAIZE

D.1 Land ownership: How many hectares have you got for agricultural use, planted or break, during Spring/Summer [SS] season 2000?

(e.g., own, rent in, loan, rent out, other, etc.)

Land ownership	Irrigated Agricultural	Humidity Agricultural	Rain fed Agricultural	Animal Pastoral	Forest Land
"Ejidal"	D1100	D1200	D1300	D1400	D1500
Communal land	D1101	D1201	D1301	D1401	D1501
Small-property	D1102	D1202	D1302	D1402	D1502
Half and half take in	D1103	D1203	D1303	D1403	D1503
Half and half take out	D1104	D1204	D1304	D1404	D1504
Rent out	D1105	D1205	D1305	D1405	D1505
Rent in	D1106	D1206	D1306	D1406	D1506
Total area	D1107	D1207	D1307	D1407	D1507

D.2 How many plots have you got with maize and other crops during (SS) 2001, including courtyard?

Plot name	D2100	D2200	D2300	D2400
Land type: **1=Irrigation, 2=Rain-fed, 3=humidity**	D2101	D2201	D2301	D2401
Production system: **1=Plow, 2=Stick (stony), 3=Other (specify)**	D2102	D2202	D2302	D2402
Land ownership: **1=Own, 2=Rent, 3=Loan, 4=Half and half, 5=Other (specify)**	D2103	D2203	D2303	D2403
Stony: **0=Nothing, 1=Little, 2=Regular, 4=Much**	D2104	D2204	D2304	D2404
Slope: **1=Flat, 2=Slope (Hills)**	D2105	D2205	D2305	D2405
Total area (ha. or local measure)	D2106	D2206	D2306	D2406
How do you consider this land quality? **1=Good, 2=Regular, 3=Bad**	D2107	D2207	D2307	D2407
Land type: **1=Black, 2=Red, 3=Yellow, 4=Rock fragment, 5=Mud, 6=Lowland, 7=Sandy, 8=White, 9=Other**	D2108	D2208	D2308	D2408
Area - land type 1	D2109	D2209	D2309	D2409
Crop(s) sown this year 2001: **1=Maize (Type) _______, 2=Beans, 3=Coffee, 4=Squash, 5=Sesame, 6=Rice, 7=Chili, 8=Cacao, 9=Groundnut, 10=Tomato, 11=Vegetable, 12=Hibiscus, 13=Other**	D2110	D2210	D2310	D2410
How did you plant the maize? **1=Intersperse, 2=Separate**	D2111	D2211	D2311	D2411

Area - land type 2	D2112	D2212	D2312	D2412
Crop(s) sown this year 2001: **1=Maize (Type) ________, 2=Beans, 3=Coffee, 4=Squash, 5=Sesame, 6=Rice, 7=Chili, 8=Cacao, 9=Groundnut, 10=Tomato, 11=Vegetable, 12=Hibiscus, 13= Other**	D2113	D2213	D2313	D2413
How did you plant the maize? **1=Intersperse, 2=Separate**	D2114	D2214	D2314	D2414

D.3 Section only for plots sown with Maize:

Maize type 1 (variety)	D3101	D3201	D3301	D3401	D3501
Seed quantity - (variety-1) **kg/plot**	D3102	D3202	D3302	D3402	D3502
Maize type 2 (variety)	D3103	D3203	D3303	D3403	D3503
Seed quantity - (variety-2) **kg/plot**	D3104	D3204	D3304	D3404	D3504
Maize type 3 (variety)	D3105	D3205	D3305	D3405	D3505
Seed quantity - (variety-3) **kg/plot**	D3106	D3206	D3306	D3406	D3506

D.3.1 Maize type characteristics (varieties) sown in SS season 2001 (for all the maize types cited in the previous section)

1.- Maize type sown (common name)	D3107	D3207	D3307	D3407
2.- How do you consider this maize?: **1=*Criollo*, 2=Creolized, 3=Improved and 4=Hybrid**	D3108	D3208	D3308	D3408
3.- Grain color **1=White, 2=Cream, 3=Yellow, 4=Other**	D3109	D3209	D3309	D3409
4.- What type of "Olote" **1=Olotillo, 2=Olotón, 3=Other** (refers to central part of the corn-cob)	D3110	D3210	D3310	D3410
5.- Grain form **1=Wide, 2=Thin**	D3111	D3211	D3311	D3411
6.- Grain size **1=Large, 2=Small**	D3112	D3212	D3312	D3412
7.- What is the use of this maize? (include all the parts) **1=Consumption, 2=Sell, 3=Elote 4=Fodder, 5=Fuel, 6=Other**	D3113	D3213	D3313	D3413
8.- How many years growing this seed?	D3114	D3214	D3314	D3414
9.- How did you obtain this seed? **1=Own, 2=Interchange, 3=Purchase, 4=Loan, 5=Gift.** If the seed is not own go to questions 22 to 24	D3115	D3215	D3315	D3415
10.- If the seed was own: how many years did you have with this seed? **(Years)**	D3116	D3216	D3316	D3416
11.- Where did you obtain the seed? Origin: **1=Family, 2=Friend, 3=Neighbor, 4=Store, 5=Government, 6=Stranger, 7=Other**	D3117	D3217	D3317	D3417

12.- The seed came from a bag? **(1=Yes, 0=No)**	D3118	D3218	D3318	D3418
13.- Do you know when the seed got-out from the bag? **(Years)**	D3119	D3219	D3319	D3419
14.- Did you introduced seed from other farmer into your seed pool? **(1=Yes, 0=No)**	D3120	D3220	D3320	D3420
15.- When was the last time you introduced seed? **(Years)**	D3121	D3221	D3321	D3421
16.- What was the trade or interchange? **1=Money, 2=Seed, 3=Gift, 4=Work, 5=Loan, 6=Other (specify)**	D3122	D3222	D3322	D3422
17.- Why did you introduced Seed from other farmers?	D3123	D3223	D3323	D3423
18.- Some time in the past, did you introduce new seed in your seed pool? **(1=Yes, 0=No)**	D3124	D3224	D3324	D3424
19.- When did you do it? **(Years)**	D3125	D3225	D3325	D3425
20.- Why did you introduce new seed?	D3126	D3226	D3326	D3426
21.- What was the trade or interchange? **1=Money, 2=Seed, 3=Gift, 4=Work, 5=Loan, 6=Other (specify)**	D3127	D3227	D3327	D3427
In the case that the seed was not your own: 22.- Where did you get the seed for the last cycle? **1=Family, 2=Friend, 3=Neighbor, 4=Store, 5=Government, 6=Stranger, 7=Other**	D3128	D3228	D3328	D3428
23.- Where did you get the seed for the last cycle? **1=Same place, 2=Other place same municipality, 3=Other municipality, 4=Other**	D3129	D3229	D3329	D3429
24.- What was the trade or interchange? **1=Money, 2=Seed, 3=Gift, 4=Work, 5=Loan, 6=Other (specify)**	D3130	D3230	D3330	D3430
25.- Did you give or sale this kind of seed to other farmers? **(1=Yes, 0=No)**	D3131	D3231	D3331	D3431
26.- If yes, what was the trade or interchange? **1=Seed, 2=Money, 3=Gift, 4=Other**	D3132	D3232	D3332	D3432
27.- With whom? **1=Family, 2=Friend, 3=Neighbor, 4=Store, 5=Government, 6=Stranger, 7=Other**	D3133	D3233	D3333	D3433
28.- Where did you do it? **1=Same place, 2=Other place same municipality, 3=Other municipality, 4=Other**	D3134	D3234	D3334	D3434

D.4 Maize seed selection:

1.- Did you select the seed? **1=Yes, 0=No** ___ (DH4101)

2.- Did you separate the seed from the rest of harvest? **1=Yes, 0=No** ___ (DH4102)

3.- Who selected the seed? **1=Farmer, 2=Farmer's spouse, 3=both, 4=Other person (specify)** ______ (DH4103)

4.- Where did you select the seed? **1=Field, 2=Household, 3=Both, 4=Other place (specify)** _____________ (DH4104)

5.- When did you select the seed? **1=Before harvest, 2=Just after harvest, 3=Between harvest and plant season, 4=Just before planting season, 5=In the field and with plant's help** ______ (DH4105)

6.- For the seed selection in the field, what aspects did you pay attention to? **1=Health seed** ______ (DH4106); **2=Corn cob size** ______ (DH4107); **3=Grain color** ________ (DH4108); **4=Wide grain** _____ (DH4109); **5=Good husk cover** _______ (DH4110); **6=Grain type** _______ (DH4111); **7=Other** ______ (DH4112)

7.- Seed-selection: from which part of the corn cob did you chose the grain? **1=Top** _____ (DH4113); **2=Center** ______ (DH4114); **3=Bottom** _____ (DH4115)

8.- How did you store the seed? **1=In cob, 2=To shell (in grain), 3=Other (specify)** __________ (DH4116)

9.- Where did you storage the seed? **1=Under cover, 2=Bag or sack, 3=Metallic silo, 4=Other (specify)** ___________ (DH4117)

10.- Did you apply chemical products for storage of your seed? **1=Yes, 0=No** ___ (DH4118)

D.4.1 Grain storage:

11.- How did you store the grain? **1=In cob, 2=To shell (in grain), 3=Other (specify);** ________ (DH4119) 12.- How did you shell? **1=Shell manual, 2=Shell machine, 3=Shell stone, 4=Other (specify)** _________ (DH4120) 13.- Where did you store the grain? **1=Under Cover; 2=Bag or sack; 3=Metallic silo; 4=Other (specify)** ____________ (DH4121) 14.- Did you apply chemical product for storage of the grain? **1=Yes, 0=No** _____ (DH4122)

D.5 Maize type characteristics:

Maize type name: **(Local name)**	DH5100	DH5200	DH5300	DH5400	DH5500
What was the best yield of this maize? **(t/ha)**	DH5101	DH5201	DH5301	DH5401	DH5501
What was the worst yield of this maize included zero? **(t/ha)**	DH5102	DH5202	DH5302	DH5402	DH5502
What is the common yield of this maize? **(t/ha)**	DH5103	DH5203	DH5303	DH5403	DH5503
What was the weight by Lt. of maize? **(kg/lt.)**	DH5104	DH5204	DH5304	DH5404	DH5504
Number of "tortillas" by lt. **(Number)**	DH5105	DH5205	DH5305	DH5405	DH5505
How many days does flowering take? (number of days) **(Days)**	DH5106	DH5206	DH5306	DH5406	DH5506
How many days for ripening? (number of days) **(Maturity)**	DH5107	DH5207	DH5307	DH5407	DH5507

D.6 Offer of characteristics for each variety:

Agronomic characteristics (a)	Variety	Variety	Variety	Variety	Variety	Hybrid from bag	Improved from bag
Have you sown this?	DH6101	DH6201	DH6301	DH6401	DH6501	DH6601	DH6701
Lodging resistance	DH6102	DH6202	DH6302	DH6402	DH6502	DH6602	DH6702
Drought tolerance	DH6103	DH6203	DH6303	DH6403	DH6503	DH6603	DH6703
Tolerance to excess rainfall	DH6104	DH6204	DH6304	DH6404	DH6504	DH6604	DH6704
Ear rot resistant	DH6105	DH6205	DH6305	DH6405	DH6505	DH6605	DH6705
Duration (growing cycle)	DH6106	DH6206	DH6306	DH6406	DH6506	DH6606	DH6706
Field pest resistance	DH6107	DH6207	DH6307	DH6407	DH6507	DH6607	DH6707
Consumption characteristics (a)							
Good for consumption	DH6108	DH6208	DH6308	DH6408	DH6508	DH6608	DH6708
Good for “tole”(beverage)	DH6109	DH6209	DH6309	DH6409	DH6509	DH6609	DH6709
Good for “elotes” for sale and consumption	DH6110	DH6210	DH6310	DH6410	DH6510	DH6610	DH6710
Good for “antojitos” (special maize preparation)	DH6111	DH6211	DH6311	DH6411	DH6511	DH6611	DH6711
Ease of shelling	DH6112	DH6212	DH6312	DH6412	DH6512	DH6612	DH6712
Good for “nixtamal”	DH6113	DH6213	DH6313	DH6413	DH6513	DH6613	DH6713
Good for fodder	DH6114	DH6214	DH6314	DH6414	DH6514	DH6614	DH6714
Storage pest resistant	DH6115	DH6215	DH6315	DH6415	DH6515	DH6615	DH6715
Produces even in a bad season (yield reliability)	DH6116	DH6216	DH6316	DH6416	DH6516	DH6616	DH6716
Good for sale	DH6117	DH6217	DH6317	DH6417	DH6517	DH6617	DH6717
Productivity: (a)							
Yield for tortilla	DH6118	DH6218	DH6318	DH6418	DH6518	DH6618	DH6718

Yield by weight	DH6119	DH6219	DH6319	DH6419	DH6519	DH6619	DH6719
Yield by volume	DH6120	DH6220	DH6320	DH6420	DH6520	DH6620	DH6720
Management characteristics: (b)							
Money demanding (invest money)	DH6121	DH6221	DH6321	DH6421	DH6521	DH6621	DH6721
Labor demanding (invest labor)	DH6122	DH6222	DH6322	DH6422	DH6522	DH6622	DH6722

(a) **1=Very good, 2=Good, 3=Bad, 4=Very bad, 5=does not known/without opinion**. (b) **1=little, 2=much**

D.7 Maize abandonment and/or lost: What maize types do you remember to have sown in the past which now nobody plants?

Name of maize abandonment or lost **(Local name)**	DH7101	DH7201	DH7301	DH7401	DH7501
When did you lose it? Years ago **(Years)**	DH7102	DH7202	DH7302	DH7402	DH7502
Why did you not plant this maize anymore?	DH7103	DH7203	DH7303	DH7403	DH7503
Would you like to grow this maize again? **1=Yes, 0=No**	DH7104	DH7204	DH7304	DH7404	DH7504
Why would you like to grow this maize again?	DH7105	DH7205	DH7305	DH7405	DH7505
Why not?	DH7106	DH7206	DH7306	DH7406	DH7506

D.8 Importance of characteristics (Demand):

Please, indicate generally how important the next set of characteristics of the maize that you plant.

Agronomic characteristics (a)	Evaluation: **1=Very important, 2=Important, 3=No important, 4=Without opinion**
Lodging resistance	DH8101
Drought tolerance	DH8102
Tolerance to excess rainfall	DH8103
Ear rot resistance	DH8104
Duration (growing cycle)	DH8105
Field pest resistant	DH8106
Consumption characteristics(a)	
Good for consumption	DH8107
Good for “atole”	DH8108
Good “elotes” for sale and consumption	DH8109
Good for “antojitos” (especial maize preparation)	DH8110
Ease of shelling	DH8111

Good for "nixtamal"	DH8112
Good for fodder	DH8113
Storage pest resistance	DH8114
Produced even in a bad season (yield reliability)	DH8115
Good for sale	DH8116
Yields characteristics (a)	
Yield for "tortilla" dough	DH8117
Yield by weight	DH8118
Yield by volume	DH8119
Management characteristics (b)	
Money demanding (invest money)	DH8120
Labor demanding (invest labor)	DH8121

(a) **1=Very good, 2=Good, 3=Bad, 4=Very bad 5=does not known/without opinion**. (b) **1=little, 2=much**

SECTION E: CREOLIZED

E.1 Spring/Summer (SS) season 2001:

Maize (variety)	EH1101	EH1201	EH1301	EH1401
If you grow the same seed for many years: What happens with the variety? **1=Improve, 2=No change, 3=Degeneration, 4=Improve for certain characteristics but worse for others**	EH1102	EH1202	EH1302	EH1402
Please, explain only if it does not change	EH1103	EH1203	EH1303	EH1403
What is the cost of the maize seed? "Pesos"/kg. May–June 2001	EH1104	EH1204	EH1304	EH1404
If you have money: Is it easy to find the seed? **1=Easy, 2=Difficult**	EH1105	EH1205	EH1305	EH1405
What was the price for this type of maize?	EH1106	EH1206	EH1306	EH1406
Grain to sale in February 2001? ($MX)	EH1107	EH1207	EH1307	EH1407
Grain to sale in July of 2001? ($MX)	EH1108	EH1208	EH1308	EH1408
Grain to buy in February 2001? ($MX)	EH1109	EH1209	EH1309	EH1409
Grain to buy in July 2001? ($MX)	EH1110	EH1210	EH1310	EH1410
Maize to sale for animal feed –fodder- in July 2001? ($MX)	EH1111	EH1211	EH1311	EH1411
Maize to sale for animal feed –fodder- in March 2001? ($MX)	EH1112	EH1212	EH1312	EH1412
Maize to buy for animal feed –fodder- in July 2001? ($MX)	EH1113	EH1213	EH1313	EH1413
Maize to buy for animal feed –fodder- in March 2001? ($MX)	EH1114	EH1214	EH1314	EH1414

1.- If you get money to buy, what kind of seed would you like?
2.- What kind of maize seed will you buy? _______________________ (EH2101) 3.- Why this kind of seed? _______________ (EH2102)
4.- Do you keep and grow the same maize variety that you have right now? **1=Yes, 0=No** _____(EH2103) If is yes: 5.- Why? _____________ (EH2104) 6.- What do you do if the maize seed get degenerate? ____ (EH2105)

SECTION F: KNOWLEDGE

F.1 Improvement practices:

1.- Do you know how the maize sexual reproduction is? **1=Yes, 0=No** _____ (FH101). 2.- How the sexual reproduction is? _________ (FH102)
3.- Do you believe that the maize plant has gender like humans? **1=Yes, 0=No** _____ (FH103)
4.- On the field: how do you difference between maize male and female? ____ (FH104)
5.- On one maize plot: how do you difference one maize plant male from one plant female? ______________________________ (FH105)
6.- Do you believe that maize landraces can be improved? **1=Yes, 0=No** ____ (FH106) 7.- How? ____________________________ (FH107)
____ (FH108)
8.- How does maize cross? (e.g., if we want cross the maize from Mr. Garcia to maize from Mr. Ruiz, how we can do it) _________ (FH109)

F.2 From the village's maize or local maize:

9.- We can select one faster seed? **1=Yes, 0=No** ____ (FH110) 10.- How? _________________________________ (FH111)
11.- We can select one intermediate seed? **1=Yes, 0=No** _____ (FH112) 12.- How? ___________________________________ (FH113)
13.- We can take or select one latest seed? **1=Yes, 0=No** _____ (FH114) 14.- How? ____________________________________ (FH115)

SECTION G: TECHNICAL CONSULTANCY

In the last five years did you receive technical consultancy about maize production:

	1=Yes, 2=No	How do you consider the information? **1=Useful, 2=No useful**
1.- Agricultural extension program	FH201a	FH201b
2.- Government program	FH202a	FH202b
3.- Store or salesman	FH203a	FH203b
4.- Salesman from one seed's company	FH204a	FH204b
5.- Other (specify)	FH205a	FH205b

SECTION H: PROGRAMS

In the last five years; did you have access to some government program?

Which one?	Access: **1=Yes, 0=No**	Since when? **(Year of participation)**	Year when the participation ends
PROCAMPO	FH301a	FH301b	FH301c
Alianza para el Campo (K x K)	FH302a	FH302b	FH302c
Progresa	FH303a	FH303b	FH303c
Other (specify)	FH304a	FH304b	FH304c

SECTION I: ANIMAL HOLDING

Did you have some of these animals in January 2001?

Animal	Approximately how many?
Yoke (pair of oxen)	G101
Cows	G102
Head of cattle	G103
Horse	G104
Donkey	G105
Pigs	G106
Poultry	G107
Goat	G108
Sheep	G109

SECTION J: AGRICULTURAL TOOLS

Agricultural tools	**1=Yes, 0=No**	Agricultural tools **(Others)**	**1=Yes, 0=No**
Spade	J101	Hoe	J104
Plow **(1=Animal, 2=Tractor)**	J102	Stick (or Spade)	J105
Sprinkling pump	J103	Other (specify)	J106

SECTION K: FIELD MANGEMENT

K.1 Plot management, ("Milpa" selected by the farmers) from table D.2:

1.- How many years have you been cultivating this plot? _______ **Years** (K1100)
2.- When was the last time it was on break? _____ **Year** (K1101)
3.- For how long was it on break? _____ **Years** (K1102)

K.2 Information for the SS season 2001 only:

Plot's land preparation (Milpa)

Did you clean the stubble of last harvest? **1=Yes, 0=No**	(K1103)	Who participated? **1=Male, 2=Woman, 3=Son, 4=Workers**	(K1104)	How did you do it? **1=Manual, 2=Animal, 3=Tractor**	(K1105)
Did you burn the stubble? **1=Yes, 0=No**	(K1106)	Who participated? **1=Male, 2=Woman, 3=Son, 4=Workers**	(K1107)	How did you do it? **1=Manual, 2=Animal, 3=Tractor**	(K1108)
Did you fallow the plot area? **1=Yes, 0=No**	(K1109)	Who participated? **1=Male, 2=Woman, 3=Son, 4=Workers**	(K1110)	How did you do it? **1=Manual, 2=Animal, 3=Tractor**	(K1111)
Did you track the land? **1=Yes, 0=No**	(K1112)	Who participated? **1=Male, 2=Woman, 3=Son, 4=Workers**	(K1113)	How did you do it? **1=Manual, 2=Animal, 3=Tractor**	(K1114)
Did you plow the land? **1=Yes, 0=No**	(K1115)	Who participated? **1=Male, 2=Woman, 3=Son, 4=Workers**	(K1116)	How did you do it? **1=Manual, 2=Animal, 3=Tractor**	(K1117)
Did you do other activity?____ **1=Yes, 0=No**	(K1118)	Who participated? **1=Male, 2=Woman, 3=Son, 4=Workers**	(K1119)	How did you do it? **1=Manual, 2=Animal, 3=Tractor**	(K1120)
Plant dates:	(K1121)	Who participated? **1=Male, 2=Woman, 3=Son, 4=Workers**	(K1122)	How did you do it? **1=Manual, 2=Animal, 3=Tractor**	(K1123)
Type of land **1=Dry,** **2=Humidity (rain-fed),** **3=Humidity lowland**	(K1124)	Who participated? **1=Male, 2=Woman, 3=Son, 4=Workers**	(K1125)	Plant method **1=Manual/spade,** **2=Machine /yoke pair of oxen,** **3=Seeder machine/tractor,** **4=Other (specify)**	(K1126)

1.- How did you plant the maize? **1=Maize alone, 2=Maize intercalate** ________ (K1127)
2.- If the maize was intercalate, what was the other crop? **1=Squash,** kg. ____ or local measurement ________ (K1128)
2=Beans, kg. ____ or local measurement ________ (K1129)
3=Coffee, kg. ____ or local measurement ________ (K1130)
4=Other kg. ____ or local measurement ________ (K1131)

K.3 Fertilizer use:

1.- Did you apply chemical fertilizer? **1=Yes, 0=No** ______ (K1132) 2.- How many times? _____ (K1133)

Product of first application? **1=Urea, 2=Sulfato, 3=Other (specify)**	(K1134)	Quantity of product? Kg or lt.	(K1135)	What was the plant size when you applied?	(K1136)	Who participated? **1=Male, 2=Woman, 3=Son, 4=Workers**	(K1137)
Which product on the second application? **1=Urea, 2=Sulfato, 3=Other (specify)**	(K1138)	Quantity of product? Kg or lt.	(K1139)	What was the plant size when you applied?	(K1140)	Who participated? **1=Male, 2=Woman, 3=Son, 4=Workers**	(K1141)

3.- Did you weed out the plot? **1=Yes, 0=No** ______ 4.- How many times? ____ (K1142)

How did you do the weeding? (first round): **1=Spade, 2=Yoke of pair of oxen, 3=Herbicide, 4=Other (specify)**	(K1143)	Quantity of product? Kg or lt.	(K1144)	What was the plant size when you applied?	(K1145)	Who participated? **1=Male, 2=Woman, 3=Son, 4=Workers**	(K1146)
How did you do the weeding (second round): **1=Spade, 2=Yoke of pair of oxen, 3=Herbicide, 4=Other (specify)**	(K1147)	Quantity of product? Kg or lt.	(K1148)	What was the plant size when you applied?	(K1149)	Who participated? **1=Male, 2=Woman, 3=Son, 4=Workers**	(K1150)

4.- Did you apply organic fertilizer (manure)? **1=Yes, 0=No** __________ (K1151) 5.- Area with manure by year ________ **ha** (K1152)

K.4 Weed killer (Herbicide):

1.- Did you apply weed killer (herbicide)? **1=Yes, 0=No** _______ (K1153)

Number of applications	Name of the weed-killer or herbicide	Quantity of herbicide **(lt. o kg)**	What was the plant size when you applied the herbicide?	Who participated? **1=Male, 2=Woman, 3=Son, 4=Workers**
1.	(K1154)	(K1155)	(K1156)	(K1157)
2.	(K1158)	(K1159)	(K1160)	(K1161)

K.5 Insecticide:

1.- Did you apply plague-soil control? **1-Yes, 0=No** _________ (K1162)

Number of applications	Name of the plague soil control	Quantity of plague soil control	Date of application of plague-soil control?	Who participated? **1=Male, 2=Woman, 3=Son, 4=Workers**
1.	(K1163)	(K1164)	(K1165)	(K1166)
2.	(K1167)	(K1168)	(K1169)	(K1170)

K.6 Harvest (collection):

1.- Date of harvest **(month/week)** ______ (K1171)
2.- Which of the family members participated? **1=Farmer, 2=Spouse, 3=Son/Daughter, 4=Workers; 5=Other** ___________ (K1172)
3.- Number of the workers for maize harvest for this plot: ______ (K1173). Cost by worker _____ **$/day** (K1174)
4.- What is the yield in this plot? **kg/ha** ___ (K1175); or **ton/ha**______ (K1176)
5.- How did you transport the harvest from the plot to home? **1=Donkey, 2=Cart (wagon), 3=Vehicle, 4=Other** _____ (K1177)
6.- What is the cost of the transportation per ton.? ________ **$/ton** (K1178) or cost by ________ **$/sack/bag** (K1179)

SECTION L: VULNERABILITY

1.- What is the significance of these problems in the maize production as well as your family welfare?

Climate or weather	L1101	Pest	L1105
Local traders "Coyotes"	L1102	Need of land	L1106
Cost production	L1103	Availability of manpower (labor needed)	L1107
Price for sale	L1104	Other (specify)	L1108

1=Very important, 2=Important, 3=No-Important

SECTION M: CONSUMPTION (MANPOWER FINANCY)

M.1 In the last five years what is more frequent in your maize production for your family:

1.- The maize out-put is greater than the quantity required for your family consumption and animals feed (Food + Feed)?__________ (M1101)
2.- The maize out-put is smaller than the quantity required for your family consumption and animals feed (Food + Feed)? _________ (M1102)
3.- Did you sale your maize? **1=Yes, 0=No** ______ (M1103) 4.- Whom did you sale your maize out-put? **1=Local trader, 2=Community families, 3=Government, 5=Other (specify)** ___________ (M1104)
5.- What percentage did you sale from your maize production? **1=Less than half, 2=Half, 3=More than half** _____________ (M1105)

M.2 In the last five years what is more frequent:

1.- Was the maize produced only by family labor? **1=Yes, 0=No** ______ (M1106) 2.- Was the maize produced only by hired labor? **1=Yes, 0=No** ______ (M1107) 3.- Was the maize produced only by hired and family labor? **1=Yes, 0=No** ______ (M1108)

M.3 From where did you obtain the money to produce your "Milpa"?

1=Informal credit (local) _____ (M1109), **2=Local moneylender** _______ (M1110), **3=In-put store** _______ (M1111), **4=Out or foreign resources** _____ (M1112), **5=Own resources** _______ (M11113), **6=Other (specify)** _______ (M1114).

SURVEY FOR FARMERS OF THE REGION COAST OF OAXACA AND FRAILESCA OF CHIAPAS, ON CREOLIZATION OF IMPROVED TUXPEÑO GERMPLASM

CIMMYT

F

CIMMYT – Mexico 2001

SECTION A: IDENTIFICATION

Unique farmer registration code (UFRC): _____________ (A1) Enumerator name: ____________________________________ (A2)

	Village name	Household address	M or F	Date	Survey number
Identification	A3	A4	A5	A6 / /	A7

Information about the respondents (**FARMER'S SPOUSE**):

Name	AM8
Age **(Years)**	AM9
Education **(Years in school)**	AM10
Mother tongue (a)	AM11
Read and write **(1=Yes, 0=No)**	AM12
Household position (b)	AM13
From the village or immigrant (c)	AM14
1=Ejidatario, 2=Settler	AM15

(a) 1=Spanish, 2=Mixteco, 3=Chatino, and 4=Other (specify) _____________
(b) 1=Head, 2=Wife, 3=Son/Daughter, and 4=Other (specify) _________________
(c) 1=Community, 2=immigrant, 3=Other (specify) ______________________
How long have you lived in this village? ______ **(Years)** (AM16)

B: HOUSEHOLD MEMBERS

Name	Relationship with household head (a)	Sex (b)	Age (Years) (c)	Education (last grade) and number of years (d)	Occupation (f)		Language (g)		Does he/she live in the household? **1=Yes, 0=No**
					First activity	Second activity	Mother tongue	Other	
B11	B12	B13	B14	B15	B16a	B16b	B17a	B17b	B18
B21	B22	B23	B24	B25	B26a	B26b	B27a	B27b	B28
B31	B32	B33	B34	B35	B36a	B36b	B37a	B37b	B38
B41	B42	B43	B44	B45	B46a	B46b	B47a	B47b	B48
B51	B52	B53	B54	B55	B56a	B56b	B57a	B57b	B58
B61	B62	B63	B64	B65	B66a	B66b	B67a	B67b	B68
B71	B72	B73	B74	B75	B76a	B76b	B77a	B77b	B78
B81	B82	B83	B84	B85	B86a	B86b	B87a	B87b	B88
B91	B92	B93	B94	B95	B96a	B96b	B97a	B97b	B98
B101	B102	B103	B104	B105	B106a	B106b	B107a	B107b	B108

(a) **1=Spouse, 2=Son/Daughter, 3=Son in law, 4=Daughter in law, 5=Grandson, 6=Cousin, 7=Other**
(b) **M=Male, F=Female**
(c) **Number of years**
(d) **Primary 1-6, Secondary 7-9, High-School 10-12, University 13-16**
(f) **1=Farmer, 2=Unskilled worker, 3=Merchant, 4=Building worker, 5=Carpenter, 6=Driver, 7=Skilled worker, 8=Migrant, 9=House help, 10=Nurse, 11=Teacher, 12=Student, 13=Other (specify)** ______
(g) **1=Spanish, 2=Mixteco, 3=Chatino, 4=Other (specify)** ____________________

SECTION C: HOUSEHOLD LIFE STRATEGY IN THE LAST FIVE YEARS

Activity (Continue…)	**1=Yes, 0=No**	**1=Priority, 0=No Priority**
Maize	CM101	CM101a
Beans	CM102	CM102a
Coffee	CM103	CM103a
Squash	CM104	CM104a
Vegetables	CM105	CM105a
Fruit tree	CM106	CM106a
Other (specify)	CM107	CM107a
Dairy cattle	CM108	CM108a
Mexican turkey cock	CM109	CM109a
Chicken	CM110	CM110a
Pork	CM111	CM111a
Shrimp	CM112	CM112a

Activity (Conclude)	**1=Yes, 0=No**	**1=Priority, 0=No Priority**
Fishing	CM113	CM113a
Handicrafts	CM114	CM114a
Baker	CM115	CM115a
“Tamales” preparation and sell	CM116	CM116a
Meal preparation and sell	CM117	CM117a
Tailor and confection	CM118	CM118a
Wash clothes	CM119	CM119a
Merchant	CM120	CM120a
Temporal migration (one season inside the community, and other season outside)	CM121	CM121a
Permanent migration (Remittances by family members)	CM122	CM122a

1.- Comparing to 10 years ago, how is yours family welfare? **Better** ___ (CM123), **Equal** ___ (CM124), **Worse** ___ (CM125)

2.- Why? ____ (CM126)

SECTION D: MAIZE

From Male survey section D.3.1 Maize type characteristics sown in Spring-Summer (SS) season 2001:

Maize variety	DM3112	DM3212	DM3312	DM3412
1.- What is the use of this maize? (include all the maize parts) **1=Consumption, 2=Sell, 3="Elote" 4=Fodder, 5=Fuel, 6=Other**	DM3113	DM3213	DM3313	DM3413
2.- How did you obtain this seed? **1=Own, 2=Interchange, 3=Purchase, 4=Loan, 5=Gift.** If the seed is own go to question 6.	DM3115	DM3215	DM3315	DM3415
If the seed is not own: 3.- From whom did you obtain this seed? **1=Family, 2=Friend, 3=Neighbor, 4=Store, 5=Government, 6=Strange, 7=Other**	DM3128	DM3228	DM3328	DM3428
4.- From where did you obtain this seed? **1=Same place, 2=Other place same municipality, 3=Other municipality, and 4=Other**	DM3129	DM3229	DM3329	DM3429
5.- What was the interchange? **1=Money, 2=Seed, 3=Gift, 4=Work, 5=Load, 6=Other (specify)**	DM3130	DM3230	DM3330	DM3430
6.- Did you give or sale this kind of seed to other farmers? **(1=Yes, 0=No)**	DM3131	DM3231	DM3331	DM3431
7.- If yes: what was the trade or interchange? **1=Seed, 2=Money, 3=Gift, 4=Other**	DM3132	DM3232	DM3332	DM3432
8.- With whom? **1=Family, 2=Friend, 3=Neighbor, 4=Store, 5=Government, 6=Strange, 7=Other**	DM3133	DM3233	DM3333	DM3433
9.- Where? **1=Same place, 2=Other place same municipality, 3=Other municipality, 4=Other**	DM3134	DM3234	DM3334	DM3434

D.4 Maize seed selection:

1.- Did you select the seed? **1=Yes, 0=No** ___ (DM4101) 2.- Did you separate the seed from the rest of harvest? **1=Yes, 0=No** ___ (DM4102)

3.- Who selected the seed? **1=Farmer, 2=Farmer's spouse, 3=both, 4=Other person (specify)** ______ (DM4103)

4.- Where did you select the seed? **1=Field, 2=Household, 3=Both, 4=Other place (specify)** ____________ (DM4104)

5.- When did you select the seed? **1=Before harvest, 2=Just after harvest, 3=Between harvest and plant season,**
4=Just before plant season, 5=In the field and with plant's help ______ (DM4105)

6.- For the seed selection in the field, what aspects did you pay attention to? **1=Health seed** _____ (DM4106); **2=Corn cob size** _____ (DM4107); **3=Grain color** _______ (DM4108); **4=Wide grain** _____ (DM4109); **5=Good husk cover** ______ (DM4110); **6=Grain type** ______ (DM4111); **7=Other** _____ (DM4112)

7.- Seed-selection: from which part of the corn cob did you chose the grain? **1=Top** ____ (DM4113), **2=Center** _____ (DM4114), **3=Bottom** _____ (DM4115)

8.- How did you store the seed? **1=In cob, 2=To shell (in grain), 3=Other (specify);** __________ (DM4116)

9.- Where did you store the seed? **1=Under cover, 2=Bag or sack, 3=Metallic silo, 4=Other (specify)** ___________ (DM4117)

10.- Did you apply chemical products for storage your seed? **1=Yes, 0=No** ___ (DM4118)

D.4.1 Grain storage:

11.- How did you store the grain? **1=In cob, 2=To shell (in grain), 3=Other (specify);** ________ (DM4119)

12.- How did you shell? **1=Shell manual, 2=Shell machine, 3=Shell stone, 4=Other (specify)** _________ (DM4120)

13.- Where did you store the grain? **1=Under cover, 2=Bag or sack, 3=Metallic silo, 4=Other (specify)** ____________ (DM4121)

14.- Did you apply chemical product for storage of the grain? **1=Yes, 0=No** _____ (DM4122)

D.5 Maize type characteristics:

Maize type name: **(Local name)**	DM5100	DM5200	DM5300	DM5400	DM5500
What is the weight of one lt. of this maize? **(kg/lt.)**	DM5104	DM5204	DM5304	DM5404	DM5504
How many “tortillas” can you make with one liter of maize? **(Number)**	DM5105	DM5205	DM5305	DM5405	DM5505

D.6 Offer of characteristics for each variety:

Agronomic characteristics (a)	Variety	Variety	Variety	Variety	Variety	Hybrid from bag	Improved from bag
Have you been sown this?	DM6101	DM6201	DM6301	DM6401	DM6501	DM6601	DM6701
Lodging resistance	DM6102	DM6202	DM6302	DM6402	DM6502	DM6602	DM6702
Drought tolerance	DM6103	DM6203	DM6303	DM6403	DM6503	DM6603	DM6703
Tolerance to excess rainfall	DM6104	DM6204	DM6304	DM6404	DM6504	DM6604	DM6704
Ear rot resistance	DM6105	DM6205	DM6305	DM6405	DM6505	DM6605	DM6705
Duration (growing cycle)	DM6106	DM6206	DM6306	DM6406	DM6506	DM6606	DM6706
Field pest resistance	DM6107	DM6207	DM6307	DM6407	DM6507	DM6607	DM6707
Consumption characteristics (a)							
Good for consumption	DM6108	DM6208	DM6308	DM6408	DM6508	DM6608	DM6708
Good for “tole”(beverage)	DM6109	DM6209	DM6309	DM6409	DM6509	DM6609	DM6709
Good for “elotes” for sale and consumption	DM6110	DM6210	DM6310	DM6410	DM6510	DM6610	DM6710
Good for “antojitos” (special maize preparation)	DM6111	DM6211	DM6311	DM6411	DM6511	DM6611	DM6711
Ease of shelling	DM6112	DM6212	DM6312	DM6412	DM6512	DM6612	DM6712
Good for “nixtamal”	DM6113	DM6213	DM6313	DM6413	DM6513	DM6613	DM6713
Good for fodder	DM6114	DM6214	DM6314	DM6414	DM6514	DM6614	DM6714
Storage pest resistant	DM6115	DM6215	DM6315	DM6415	DM6515	DM6615	DM6715
Produces even in a bad season (yield reliability)	DM6116	DM6216	DM6316	DM6416	DM6516	DM6616	DM6716
Good for sale	DM6117	DM6217	DM6317	DM6417	DM6517	DM6617	DM6717
Productivity*(a)							
Yield for tortilla	DM6118	DM6218	DM6318	DM6418	DM6518	DM6618	DM6718
Yield by weight	DM6119	DM6219	DM6319	DM6419	DM6519	DM6619	DM6719
Yield by volume	DM6120	DM6220	DM6320	DM6420	DM6520	DM6620	DM6720
Management characteristics (b)							
Money demanding (invest money)	DM6121	DM6221	DM6321	DM6421	DM6521	DM6621	DM6721
Labor demanding (invest labor)	DM6122	DM6222	DM6322	DM6422	DM6522	DM6622	DM6722

(a) **1=Very good, 2=Good, 3=Bad, 4=Very bad, 5=does not known/without opinion**. (b) **1=little, 2=much**

D.7 Maize abandon and/or lost: What maize types did you remember have sown in the past which now nobody plant?

Name of maize abandoned or lost **(local name)**	DM7101	DM7201	DM7301	DM7401
When did you lose it? **(Years)**	DM7102	DM7202	DM7302	DM7402
Why did you not plant this maize anymore?	DM7103	DM7203	DM7303	DM7403
Would you like to grow again? **1=Yes, 0=No**	DM7104	DM7204	DM7304	DM7404
Why would you like to grow this maize again?	DM7105	DM7205	DM7305	DM7405
Why not?	DM7106	DM7206	DM7306	DM7406

D.8 Importance of characteristics (Demand):

Please, indicate generally what important are for you the next set of characteristics for the maize that you plant.

Agronomic characteristics (a)	Evaluation: **1=Very important, 2=Important, 3=No important, 4=Without opinion**
Lodging resistance	DM8101
Drought tolerance	DM8102
Tolerance to excess rainfall	DM8103
Ear rot resistance	DM8104
Duration (growing cycle)	DM8105
Field pest resistance	DM8106
Consumption characteristics (a)	
Good for consumption	DM8107
Good for “atole”	DM8108
Good “elotes” for sale and consumption	DM8109
Good for “antojitos” (especial maize preparation)	DM8110
Ease of shelling	DM8111
Good for “nixtamal”	DM8112
Good for fodder	DM8113
Storage pest resistance	DM8114
Produced even in a bad season (yield reliability)	DM8115
Good for sale	DM8116
Yields characteristics (a)	
Yield for “tortilla” dough	DM8117
Yield by weight	DM8118

Yield by volume	DM8119
Management characteristics (b)	
Money demanding (invest money)	DM8120
Labor demanding (invest labor)	DM8121

(a) **1=Very good, 2=Good, 3=Bad, 4=Very bad 5=does not known/without opinion**. (b) **1=little, 2=much**

SECTION E: CREOLIZED

E.1 For SS plant season 2001:

What was the price for this maize?	EM1106	EM1206	EM1306	EM1406	EM1506
Grain to sale in February 2001? ($MX)	EM1107	EM1207	EM1307	EM1407	EM1507
Grain to sale in July of 2001? ($MX)	EM1108	EM1208	EM1308	EM1408	EM1508
Grain to buy in February 2001? ($MX)	EM1109	EM1209	EM1309	EM1409	EM1509
Grain to buy in July 2001? ($MX)	EM1110	EM1210	EM1310	EM1410	EM1510
Maize to sale for animal feed –fodder- in July 2001? ($MX)	EM1111	EM1211	EM1311	EM1411	EM1511
Maize to sale for animal feed –fodder- in March 2001? ($MX)	EM1112	EM1212	EM1312	EM1412	EM1512
Maize to buy for animal feed –fodder- in July 2001? ($MX)	EM1113	EM1213	EM1313	EM1413	EM1513
Maize to buy for animal feed –fodder- in March 2001? ($MX)	EM1114	EM1214	EM1314	EM1414	EM1514

SECTION F: PROGRAMS

1.- In the last five years: did you have access to some government program?

Which one?	Access **1=Yes, 0=No**	Since when? Year of participation	Year when the participation ends
PROCAMPO	FM301a	FM301b	FM301c
Alianza para el Campo (K x K)	FM302a	FM302b	FM302c
Progresa	FM303a	FM303b	FM303c
Other (specify)	FM304a	FM304b	FM304c

SECTION G: HOUSEHOLD EXPENDITURE

G.1 Food expenditure:

In one regular week, how much did you spend or consume of the following list of products:

Concept	Quantity	Purchased **1=Yes, 0=No**	Price pay	Own production **1=Yes, 0=No**	It was a gift **1=Yes, 0=No**
Maize (grain)	G1100	G1101	G1102	G1103	G1104
Maize flour "e.g., Maseca"	G1105	G1106	G1107	G1108	G1109
Tortillas (have already elaborated)	G1110	G1111	G1112	G1113	G1114
Beans	G1115	G1116	G1117	G1118	G1119
Rice and Pasta	G1120	G1121	G1122	G1123	G1124
Milk	G1125	G1126	G1127	G1128	G1129
Tin foods (e.g., Tuna-fish, Mayonnaise,	G1130	G1131	G1132	G1133	G1134
Sugar	G1135	G1136	G1137	G1138	G1139
Coffee	G1140	G1141	G1142	G1143	G1144
Potatoes	G1145	G1146	G1147	G1148	G1149
Tomatoes	G1150	G1151	G1152	G1153	G1154
Onion	G1155	G1156	G1157	G1158	G1159
Chili	G1160	G1161	G1162	G1163	G1164
Other vegetables	G1165	G1166	G1167	G1168	G1169
Fruits (e.g., Banana, Papaya, Orange, Apples)	G1170	G1171	G1172	G1173	G1174
Bread	G1175	G1176	G1177	G1178	G1179
Beef	G1180	G1181	G1182	G1183	G1184
Pork meat	G1185	G1186	G1187	G1188	G1189
Chicken meat	G1190	G1191	G1192	G1193	G1194
Fish	G1195	G1196	G1197	G1198	G1199

SURVEY FOR FARMERS OF THE REGION COAST OF OAXACA AND FRAILESCA OF CHIAPAS, ON CREOLIZATION OF IMPROVED TUXPEÑO GERMPLASM

CIMMYT®

F&M

CIMMYT – Mexico 2001

SECTION A: IDENTIFICATION

Unique farmer registration code (UFRC): _____________ (A1). Enumerator name: ____________________________________ (A2).

	Village name	Household address	F or M	Date	Survey number
Identification	A3	A4	A5	A6 / /	A7

SECTION H: HOUSEHOLD CHARACTERISTICS

Infrastructure available	**1=Yes, 0=No**
Household possession: **1=Own, 2=Rent, 3=Loan, 4=Other**	H&M101
Drinking water: **1=Pipe, 2=Well, 3=Tap, 4=Other**	H&M 102
Connection to sewer or drain **1=Yes, 0=No**	H&M 103
Electricity (energy) **1=Yes, 0=No**	H&M 104
Household's floor type **1=Earth, 2=Cement, 3=Other**	H&M 105
The street has pavement **1=Yes, 0=No**	H&M 106
Do your children have access to primary school? **1=Yes, 0=No**	H&M 107
Do your children have access to secondary school? **1=Yes, 0=No**	H&M 108
Does your family have access to the local hospital or health services? **1=Yes, 0=No**	H&M 109
How many people live in your house and how many rooms does your house have?	H&M 110

Questionnaire for female & male (interviewed together)

H.1 In a common month in 2001, how much did you expend in the next articles:

Concept	How much	Frequency		
	$/Concept	**Weekly**	**Monthly**	**Yearly**
Electricity (Energy)	F1200	F1201	F1202	F1203
Gas	F1204	F1205	F1206	F1207
Drinking water (Bottle)	F1208	F1209	F1210	F1211
Drinking water (Municipality services)	F1212	F1213	F1214	F1215
Additional cost for drinking water	F1216	F1217	F1218	F1219
House’s mortgage or rent	F1220	F1221	F1222	F1223
Taxes (Description)	F1224	F1225	F1226	F1227
Tax type one	F1228	F1229	F1230	F1231
Tax type two	F1232	F1233	F1234	F1235
Telephone (Rent) o prepaid cards	F1236	F1237	F1238	F1239
Transportation (Bus, Taxi or Other)	F1240	F1241	F1242	F1243
Expenditure in beverages (e.g., Liquor, Beer, Soft drinks)	F1244	F1245	F1246	F1247
Expenditure on legal profession in City-Hall	F1248	F1249	F1250	F1251
Others	F1252	F1253	F1254	F1255

H.2 Education expenditure, in one normal month, more or less how much did you expend:

Name of the household member that attend the school:	Education enrollment or matriculation	Expenditure in transportation	Expenditure in housing or accommodation	Expenditure in food or meals	Expenditure in dress of scholar dress	Expenditure in scholar implements, materials, books, notebook, etcetera.
F1300	F1301	F1302	F1303	F1304	F1305	F1306
F1307	F1308	F1309	F1310	F1311	F1312	F1313
F1314	F1315	F1316	F1316	F1318	F1319	F1320
F1321	F1322	F1323	F1324	F1325	F1326	F1327

H.3 Health insurance, medical and medicines expenditures by household members in the last 12 months:

1.- Have you got Social Security? **1=Yes, 0=No** ________ (F1400) 2.- Which one? **1=SSA, 2=ISSSTE, 3=IMSS, 4=Other (Specify)** ________ (F1401)
3.- Did you pay some fee for the social security? **1=Yes, 0=No** ______ (F1402)
4.- How much? **$** ________ (F1403). 5.- Frequency? ___________ (F1404)

H.3.1 Expenditures in medicament and physicians in the last 12 months:

Concept	When? And how much?	Did you receive some refund for your expenditure? How much?	Who give you the refund?
a) Physicians	F1405	F1406	F1407
b) Medicament	F1408	F1409	F1410
c) Traditional medicament	F1411	F1412	F1413
d) Hospital	F1414	F1415	F1416
e) Other (Specify)	F1417	F1418	F1419
	F1420	F1421	F1422

H.4 Expenditures in clothing, shoes, and accessories in the last 12 months:

Concept	Bought by household members		Given by others like gift	
	Description	**Price ($)**	**Who?**	**Value estimated**
Clothing:	F1500	F1501	F1502	F1503
For man	F1504	F1505	F1506	F1507
For woman	F1508	F1509	F1510	F1511
For children	F1512	F1513	F1514	F1515
Shoes:	F1516	F1517	F1518	F1519
For woman	F1520	F1521	F1522	F1523
For man	F1524	F1525	F1526	F1527
For children	F1528	F1529	F1530	F1531
Other:	F1532	F1533	F1534	F1535
Belt, Hat, Watch, Hanging, etc.	F1536	F1537	F1538	F1539
Others	F1540	F1541	F1542	F1543
Tools for the household	F1544	F1545	F1546	F1547
Toys for children	F1548	F1549	F1550	F1551

H.5: Expenditures for kitchen staff or utensil in the last 12 months:

	Bought by household members		Given by others like gift	
	Description	**Price ($)**	**Who?**	**Value estimated**
Electronic appliance	F1552	F1553	F1554	F1555
Stove	F1556	F1557	F1558	F1559
Frying-pan	F1560	F1561	F1562	F1563
Pot / saucepan	F1564	F1565	F1566	F1567
Crockery	F1568	F1569	F1570	F1571
Blender	F1572	F1573	F1574	F1575
Refrigerator	F1576	F1577	F1578	F1579
Other	F1580	F1581	F1582	F1583
Microwave	F1584	F1585	F1586	F1587
Radio	F1588	F1589	F1590	F1591
Television	F1592	F1593	F1594	F1595
Iron	F1596	F1597	F1598	F1599
Sewing	F1600	F1601	F1602	F1603
Vehicle and parts	F1604	F1605	F1606	F1607

H.6 Expenditures for festivities or celebrations in the last 12 months:

Family, communal or what kind of celebration, comment:	**1=Wedding, 2=Baptism, 3=Anniversary XV, 4=Other**	**Traditional celebration in the community**	**If you have been the organizer**
How much did you pay?	F1608	F1609	F1610
How much did you pay for beef meat?	F1611	F1612	F1613
How much did you pay for pork meat?	F1614	F1615	F1616
How much did you pay for chicken meat?	F1617	F1618	F1619
How much did you pay for vegetables?	F1620	F1621	F1622
How much did you pay for drinks?	F1623	F1624	F1625
Did you pay for chairs, tables and crockery?	F1626	F1627	F1628
Did you pay for music or musicians?	F1629	F1630	F1631
Did you buy clothes for the celebration, how much did you pay, for yourself and family members?	F1632	F1633	F1634
Did you have other payments?	F1635	F1636	F1637
Did you collaborate as employer for the celebration, how many days?	F1638	F1639	F1640

1.- Did you receive aid or contribution for the party or celebration purpose? **1=Yes, 0=No** ______ (F1641)

2.- Did somebody from your household who participate in one celebration organization had to contribute with money, animals or gift?

1=Yes, 0=No ______ (F1642).

H.7 Expenditures for build or repair the household in the las 12 months:

1.- Did you buy a new house? **1=Yes, 0=No** _____ (F1700) 2.- How much? **$** ___________ (F1701)

3.- Did you buy a plot or field? **1=Yes, 0=No** _____ (F1702) 4.- How much? **$** __________ (F1703)

5.- Did you build, renew or repair something in your house? **1=Yes, 0=No** _____ (F1704) 6.- How much? **$** _____________ (F1705)

Did you hire labor to build, renew or repair your house?

How many workers?	F1706
How many days?	F1707
How much did you pay by day? **($/day)**	F1708

How many household members contributed to build, renew or repair the house?

How many family members?	F1709	F1710	F1711
How many days?	F1712	F1713	F1714

Did you spend money in materials (e.g. brick, cement, stick, windows, roof, and etcetera) please detail the materials that you bought.

Material	Quantity	Cost		Material	Quantity	Cost
F1715	F1716	F1717$		F1724	F1725	F1726$
F1718	F1719	F1720$		F1727	F1728	F1729$
F1721	F1722	F1723$		F1730	F1731	F1732$