UNIVERSITAT POLITÈCNICA DE CATALUNYA BARCELONATECH

Farmers' preferences and the factors affecting their decision to improve maize crops in Mexico

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CREDA
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I DESENVOLUPAMENT AGROALIMENTARI

FARMERS' PREFERENCES AND THE FACTORS AFFECTING THEIR DECISION TO IMPROVE MAIZE CROPS IN MEXICO

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UNIVERSITAT POLITÈCNICA DE CATALUNYA

CASTELLDEFELS

SPAIN

Dissertation for the degree of Doctor

from the Universitat Politècnica De Catalunya

2017

UNIVERSITAT POLITÈCNICA DE CATALUNYA
BARCELONATECH
Escola de Doctorat

Acta de calificación de tesis doctoral

Curso académico:

Nombre y apellidos

Programa de doctorado

Unidad estructural responsable del programa

Resolución del Tribunal

Reunido el Tribunal designado a tal efecto, el doctorando / la doctoranda expone el tema de su tesis doctoral titulada ____

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Barcelona, _______ de ____________________ de __________

To God

My mighty rock, the hope of my soul, my refuge and provider.

To my husband, Julio

The person God created for me.

Thanks be to God for giving us the best gift, which is each other's company.

Let us celebrate our achievements and let us keep walking always holding each other's hand.

To my daughter, Leisly

The motor of my life and the light of my eyes.

If it was possible to express how much I love you, there wouldn't be enough pages nor enough time to describe it.

When I tell you how much I love you I don't do it out of habit; I do it to remind you that you are my greatest blessing.

To my parents and sisters

You are the example I follow, my unconditional support, my strength and delight.

ACKNOWLEDGEMENTS

I would like to begin with especial thanks to my supervisor Dr. Zein Kallas Calot, who passed on his enthusiasm and passion for work. His ongoing patience, support and guidance always inspired me to go forward.

To my tutor Dr. José Ma. Gil Roig, Director of the Center for Agro-food Economy and Development (CREDA), for trusting me and always encouraging me, and for his wise advise.

To the Technical University of Cataluña (Universidad Politécnica de Cataluña), for its collaboration and for providing me with all I needed for my work, especially to the Sustainability Department.

To the institutions that have supported me in this process, especially to the Consejo Nacional de Ciencia y Tecnología (CONACYT) and to the Instituto Nacional de Investigaciones Forestales, Agrícolas y Pecuarias (INIFAP).

To the personnel at CREDA, for their kindness, support, enthusiasm and efficiency.

To my colleagues at CREDA, for the shared good times.

To Dorcas, for always being by my side, for passing on her positivity, love and for being my family in Castelldefels.

To all those who offered me their friendship, with whom I've shared unforgettable experiences, especially to Ceci and Carlina.

ABSTRACT

Mexico is one of the countries with the highest corn production in the world (24.6 million tonnes) (FAOSTAT, 2016). However, in some regions, the yields are very low (2.0 tha^{-1}) compared to the national average (9.39 tha^{-1}). Among the different strategies to improve productivity, the adoption of improved maize seeds can play an important role. However, the adoption of this type of seed in Mexico is still limited. The development of a seed sector that meets the needs of farmers is an opportunity to increase improved seed usage, productivity, and, thus, profitability of Mexican farmers. The main objective is to analyze farmers' opinions and attitudes towards the improved seeds adoption. To achieve this objective, we followed a methodological approach in three phases. Data was gathered from face-to-face survey with 200 corn farmers conducted in January and March 2015. The survey was carried out in Chiapas, one of the states with the largest area planted with maize in Mexico and the highest percentage of marginal corn outcomes. In the first phase, we analyzed farmers' decision at the production level. We also studied farmers' heterogeneity by analyzing their socioeconomic characteristics and those of their farms, attitudes and opinions towards improved seeds, their perceived risk preferences and their objectives when managing their farm. Results showed the presence of three types of farmers: "In transition," who do not fully appreciate the potential of improved seeds (52.5%); "Conservatives," with a negative perception of improved seeds (18.5%); and "Innovators," with a positive perception (29%). Each of the identified segments has its commercial strategy with differentiated objectives, although the economic objectives prevail over the rest.

In the second phase, we identified the key attributes as the main determining factors when selecting the improved varieties of maize seeds. We also indentified the farmers' willingness to pay (WTP) for each attribute and analyzed their observed heterogeneity, while taking into account several socio-economic variables. The analysis reflected that the improved seed varieties were more preferred than the Creole alternative varieties, showing a heterogeneous WTP to ensure higher yields, resistance to diseases, and larger ear size. Finally, in the last phase, we examined the determinants of the adoption rate of the improved seeds using a survival analysis. Approximately the decision of the 60% of farmers who adopted was over a period of 10 years. Young farmers with few family members and several agricultural generations that exhibited positive attitudes towards innovation and with low risk perception are likely to adopt the new varieties. Results showed that the North American Free Trade Agreement (NAFTA) in 1994 negatively affected the adoption rate of improved seeds. Results showed low knowledge level of farmers towards the advantages of improved seeds. It is necessary to improve extension tools for the efficient use of sustainable agricultural inputs and practices to accelerate the process of adopting improved seeds and to facilitate access to financing and insurance.

Keywords: Maize seed, farmers' preference, adoption, survival analysis, choice experiment, Mexico.

RESUMEN

México es uno de los países con mayor producción de maíz en el mundo (24.6 millones de toneladas) (FAOSTAT, 2016). Sin embargo, en algunas regiones los rendimientos son bajos (2,0 tha^{-1}) en comparación con el promedio nacional (9,39 tha^{-1}). Entre las diferentes estrategias para mejorar la productividad, la adopción de semillas mejoradas de maíz puede desempeñar un papel importante. Sin embargo, la adopción de este tipo de semillas en México sigue siendo limitada. El desarrollo de un sector de semillas que satisfaga las necesidades de los agricultores es una oportunidad para incrementar el uso de semillas, la productividad y, por tanto, la rentabilidad de los agricultores mexicanos. El objetivo principal es analizar las opiniones y actitudes de los agricultores hacia la adopción de semillas mejoradas. Para lograr este objetivo, seguimos un enfoque metodológico en tres fases. Los datos se recolectaron de una encuesta cara a cara con 200 agricultores de maíz realizada en enero y marzo de 2015. La encuesta se realizó en Chiapas, uno de los Estados con mayor superficie plantada de maíz en México y el mayor porcentaje de resultados marginales de maíz. En la primera fase, analizamos la decisión de los productores a nivel de producción. También estudiamos la heterogeneidad de los agricultores analizando sus características socioeconómicas y las de sus fincas, actitudes y opiniones respecto a semillas mejoradas, sus preferencias de riesgo percibidas y sus objetivos al manejar su finca. Los resultados mostraron la presencia de tres tipos de agricultores: "En transición", que no aprecian plenamente el potencial de semillas mejoradas (52,5%); "Conservadores", con una percepción negativa de semillas mejoradas (18,5%); e "Innovadores", con una percepción positiva (29%). Cada uno de los segmentos identificados tiene su estrategia comercial con objetivos diferenciados, aunque los objetivos económicos predominan sobre los demás. En la segunda fase, identificamos los atributos claves como los principales factores determinantes al seleccionar las variedades mejoradas de semillas de maíz. También identificamos la disposición de los agricultores a pagar por cada atributo y analizamos su heterogeneidad observada, teniendo en cuenta varias variables socioeconómicas. El análisis reflejó que las variedades de semillas mejoradas eran más preferidas que las variedades alternativas criollas, mostrando una WTP heterogénea para asegurar mayores rendimientos, resistencia a las enfermedades y mayor tamaño de la mazorca. Por último, en la última fase, se examinaron los determinantes de la tasa de adopción de las semillas mejoradas utilizando un análisis de supervivencia. Aproximadamente la decisión del 60% de los agricultores que adoptaron fue durante un período de 10 años. Los jóvenes agricultores con pocos miembros de la familia y varias generaciones agrícolas que mostraron actitudes positivas hacia la innovación y con una percepción de bajo riesgo probablemente adoptarán las nuevas variedades. Los resultados mostraron que el Tratado de Libre Comercio de América del Norte (TLCAN) en 1994 afectó negativamente la tasa de adopción de semillas mejoradas. Los resultados mostraron un bajo nivel de conocimiento de los agricultores hacia las ventajas de las semillas mejoradas. Es necesario mejorar las herramientas de extensión para el uso eficiente de insumos y prácticas agrícolas sostenibles para acelerar el proceso de adopción de semillas mejoradas y facilitar el acceso al financiamiento y seguros.

Palabras clave: semilla de maíz, preferencia de los agricultores, adopción, análisis de supervivencia, experimento de elección, México.

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CHAPTER 1

INTRODUCTION AND BACKGROUND

1.1 Introduction

Mexico faces the challenge to improve the sustainability of their food production systems. The continuous growth of the Mexican population makes necessary the increase of the national food production (Harrison, 2002). The National Institute of Statistics, Geography, and Informatics (INEGI, 2016) mentions that the population will double in the next 40 years, reaching 230 million people in 2050. Achieving food security for a progressive number of inhabitants is a great challenge, especially when there are important segments of the urban and rural population living temporarily or permanently in poverty (Menéndez & Palacio, 2015).

Food security is reached when a country continuously ensures the physical and economic access to sufficient, safe, and nutritious food to meet their dietary needs and preferences in order to lead an active and healthy life. In this regard, the United Nations Organization has emphasized measures that increase food production that ensure the access to food and food independency. The greater the import of basic grains that a country conducts, the higher the rate of migration, malnutrition, and unemployment (Faostat, 2016). All this means that rural people leave the sector to diversify and complement the secondary and tertiary sectors (Martínez & Vallejo, 2011).

In 2006, Mexico imported 7,584,723 tonnes of maize, while 12,134,044 tonnes are estimated to be imported at the end of 2016. That is, maize imports in the last decade have reached 59.9%. Bongaarts (1996) mentions that to ensure food security for the world's population by 2050, it would be necessary to double yields, increase area, and intensify harvest frequency. The development of maize varieties that are better adapted to the new climatic conditions is vital for future food production (Challinor et al. 2016). To increase maize productivity in Mexico, it is convenient to use affordable technologies for small producers who often require more food. An example of these technological innovations is improved corn seeds. However, the adoption of this type of seed in Mexico is still limited (30%) (Herrera et al. 2002).

To illustrate this issue, one example is the state of Chiapas, which is mainly characterized by an agricultural system dominated by small farmers and low yields of 1.6 tha^{-1} (SIAP, 2016). Further, Chiapas has the largest demand for corn seed and the highest potential for increased production; although, it is still one of the states with the lowest implementation rates of improved seeds (30%), due to the low-perceived advantage of this technology (INEGI, 2015). It is important to mention that the available technologies are not necessarily directed towards small producers, either because they are not accessible, there are no technologies adapted to their conditions, or the private initiative approach is not adequate to satisfy certain market niches. Sandoval et al. (2014) mention that governments have recognized that the main objective of seed companies is not always to serve small-scale producers, which is why it is necessary to create special programs to reach this segment in order to develop a seed supply system feasible to multiply and distribute seeds. Therefore, if the use of improved seeds is to be generalized, it is necessary to take into account the great heterogeneity of existing producers with specific differentiating circumstances, which on the other hand, condition farmers' production decisions. Among these circumstances, we can highlight the environment, natural and economic factors, business objectives, farmers' preferences and limitations on the availability of resources. If the technologies are suited to the specific circumstances of farmers, these shall take them quickly (CIMMYT, 1993).

Therefore, the main objective of this research is to analyze farmer’s attitudes and perceptions toward the improved maize seeds in Chiapas within three steps. In the first phase, we focused on the adoption behavior in this sector, analyzing the farm heterogeneity and taking into account not only their socioeconomic characteristics and those of their farms but also their attitudes and perceived risk towards improved seeds. Furthermore, the farmers´ objectives were introduced as rive factor to adoption.

Bellon (1991) showed that farmers are not a homogeneous group and their preferences and priorities are highly heterogeneous. With this in mind, many determining factors affect farmers' choice of seeds. Their selection depends on the final product attributes, socioeconomic variables, opinions and attitudes, risk perception, the sociocultural environment, and the amount of information they have access to (Hellyer et al. 2012). Morris & Bellon (2004) noted that plant breeders often have weak links to the end user. This is partly due to their professional training: plant breeders receive rigorous instruction in the theory and practice of crop improvement and have little exposure to survey methods needed to elicit structured feedback from farmers. As a result, what the conventional plant breeder considers important in a variety might not correspond with the preferences of the majority of farmers in an agricultural system or region. Consequently, the breeding program may result in selecting a non-optimal combination of characteristics. Accordingly, the best strategy to increase the improved seeds is to develop appropriate technologies that take into consideration the heterogeneity of farmers, their production constraints, and what really influences their final decisions in farming activities (Sibiya et al. 2013). Notably, the inclusion of farmers' opinions and preferences in the design and development of technological innovations is scarce in Mexico (Castillo & Chávez, 2013; Birol et al. 2009; Birol et al. 2006; Herrera et al. 2002).

Considering these findings, in order to estimate the farmers' willingness to pay for each attribute, the second phase analyzed the key attributes as the main determining factors when selecting the improved varieties of maize seeds and landraces. In the same way, it is important to mention that the local varieties are fundamental for the biodiversity that's why it is necessary to analyze to what extent farmers are willing to use the improved varieties. Therefore, farmers were asked about the percentage of the different varieties of seed they would select for their maize cultivation in a year. That is, the respondent gave preferences for two alternatives, depending on the utility that it provided, and that decision produced a percentage. In contrast to the traditional form of the choice experiment data set where respondents are asked to rank or select their preferred products used 0 and 1. It is important to mention that the success of research and development innovations occurs when farmers make effective use of technology. CIMMYT (1993) mentions that all institutions involved in the generation and transfer of agricultural technology should be able to conduct studies that document the degree of adoption and help explain the motivations of farmers.

In this context, the third phase of the research was to analyze the adoption behavior at the time of the improved maize seeds. It also seeks to identify the factors associated with the decision to adopt by establishing the relative importance of the same on this decision, using the analysis of survival. Consequently, this work seeks to provide technical, socioeconomic, and typological information of maize farmers in the state of Chiapas that serves to feedback and promote differentiated adoption strategies for this important crop in the state.

1.2 Objectives and structure of the research

Based on the above, in order to analyze the behavior of farmers towards improved maize seeds and to determine the needs and possibilities of adoption, the following objectives are proposed:

1. Characterize maize farmers by taking into account their socio-economic characteristics and those of their farms as well as their attitudes, risk preferences, and the objectives that each farmer has in his decision to manage the farm.
2. Identify the key attributes as the main determining factors when selecting the improved varieties of maize seeds and landraces, identifying the farmers' willingness to pay (WTP) for each attribute and analyzing their observed heterogeneity, while taking into account several socio-economic variables.
3. To analyze the adoption behavior over time for improved maize seeds. Likewise, it seeks to identify the associated factors with the decision to adopt, establishing the relative importance of the same on this decision.

To achieve the proposed objectives, this thesis is structured as summarized in Figure 1, highlighting the type of information required in each case and the applied analysis techniques. Each of the chapters of the thesis will try to respond to one of the objectives and are structured as scientific articles.

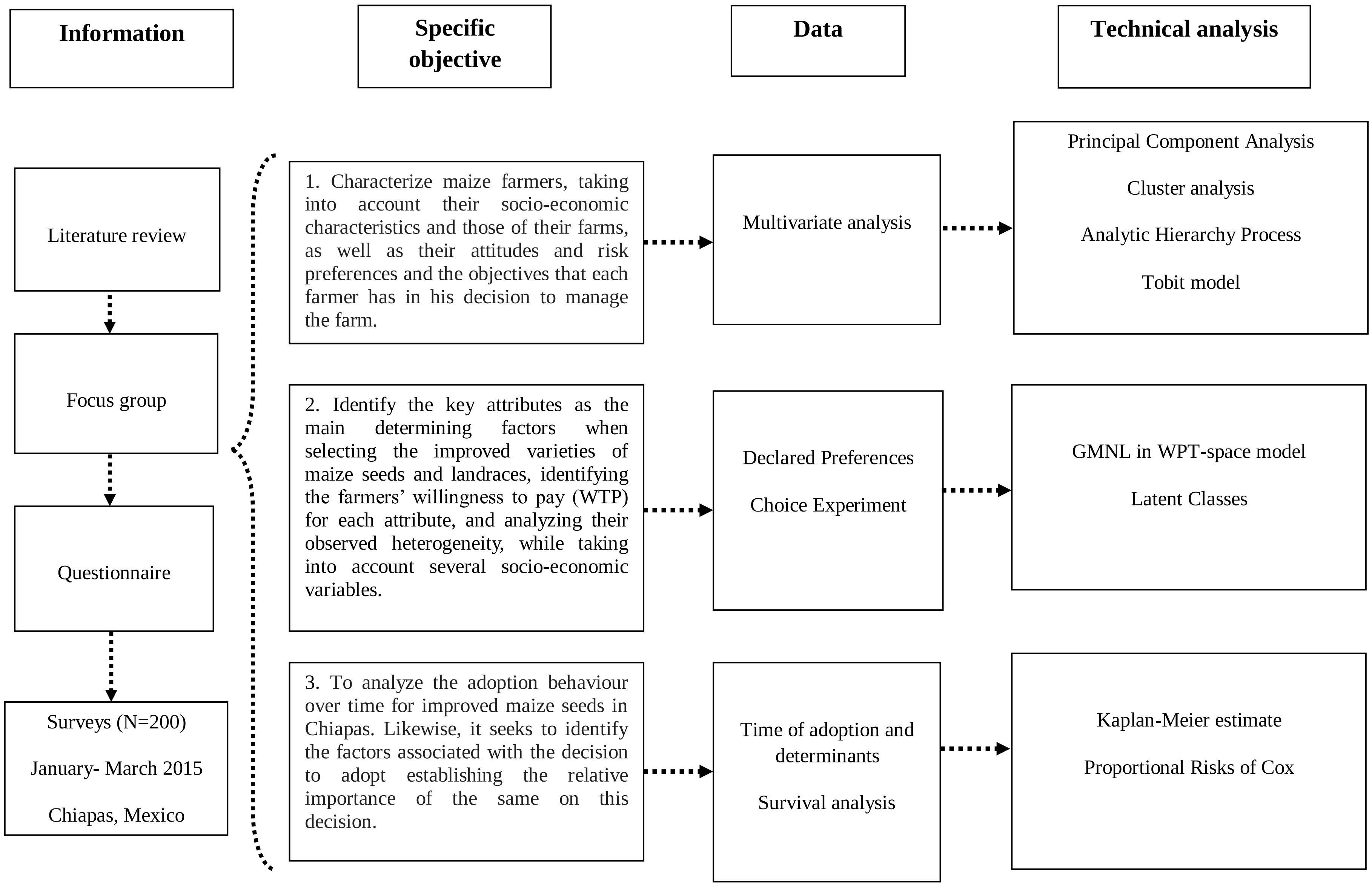

Figure 1. Structure of research

1.3 Background maize sector in Mexico

1.3.1 Overview of maize production in Mexico

In Mexico, maize is a basic crop that is sown mainly in dry conditions and at altitudes ranging from sea level to 3,000m above sea level, depending on whether an area is humid, dry tropics or otherwise. The crop is well adapted to the different ecological conditions of the country and constitutes one of the main sources of food in the Mexican population (Wise, 2008). By the end of 2016, Mexico reported an estimated 26,446,862 tonnes of corn production, ranking 4th in the world behind China, United States and Brazil. The average yield per hectare is 3.5 tonnes (78th place out of 164 countries producing this grain in the world) (FAOSTAT, 2016). Figure 2 and 3 shows the performance of maize production and yield in the last 10 years.

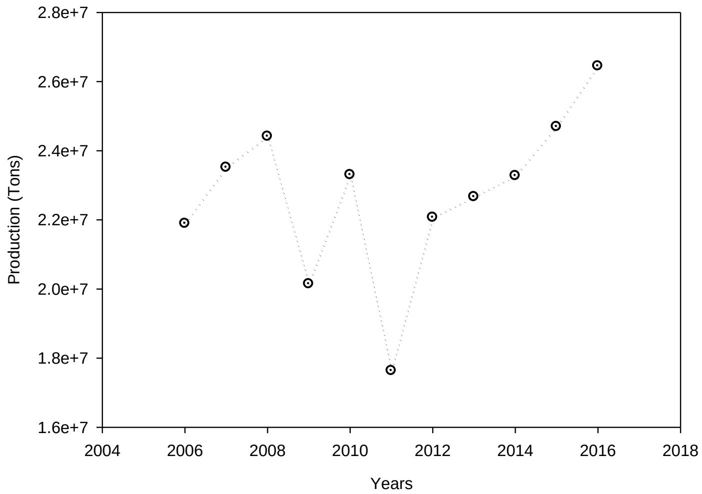

Figure 2. Behavior of maize production in Mexico

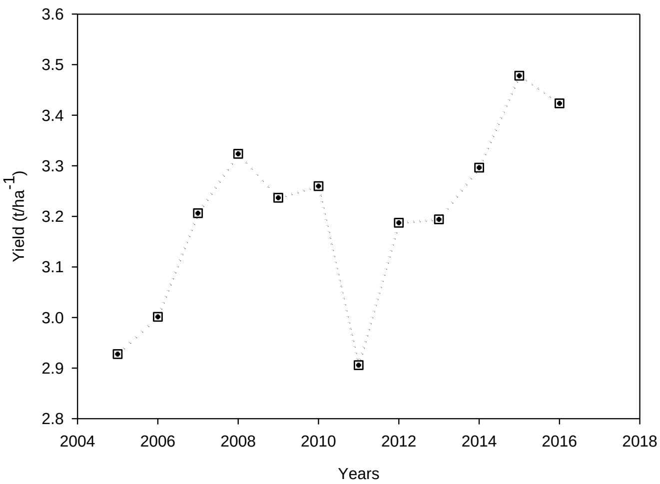

Figure 3. Behavior of maize yield in Mexico

The national production of maize is cultivated largely under the regime of temporal; however, in the last few years, the production of irrigation has increased considerably, representing an annual average growth rate three times greater than a temporal production.

As the national production, domestic corn grain consumption has recovered over the last three trading years. In 2015, consumption of grain corn grew 8.6% to annual rate to settle at 36.1 million tonnes (SAGARPA, 2015). Mexico is the largest maize market in the world, accounting for 11% of world consumption. Each Mexican consumes an average of 298.6 kg of maize annually, a figure well above the world average (16.8 kg per capita).

The proportion of the national consumption that is covered with the production generated in the country has been decreasing. In the last decade imports increased 59.9%. Mexico is an important producer of maize; but at the same time, it is also a recognized importer, especially after the North American Free Trade Agreement, since it highlights the growing trend of imports.

On the other hand, it is estimated that by the end of 2016, Mexican exports will reach 692,643 tonnes (Gobierno de México, 2015). The export volume of maize has the main destinations to Venezuela with 83.7% of the shipped volume, which represents 0.33 million tonnes; followed by the United States with 9.2%; and finally, Nicaragua with 7.0% of the total exported (Figure 4).

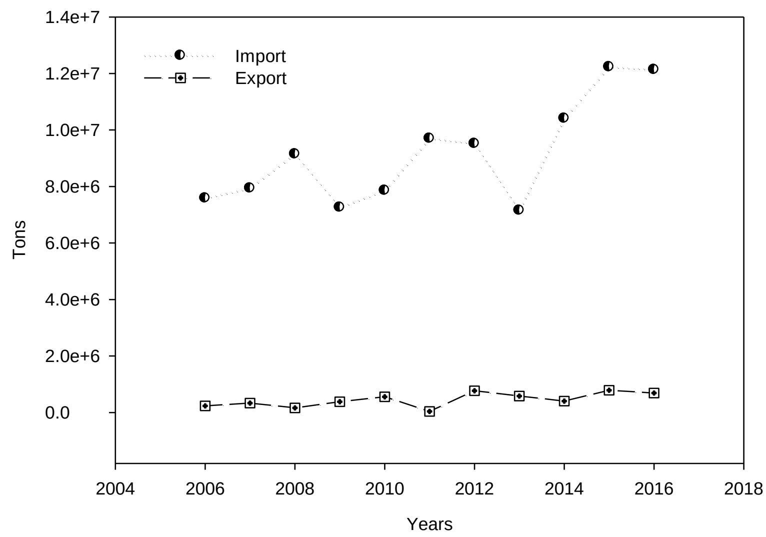

Figure 4. Maize import and exports behavior

Maize production is concentrated in all the states of the Mexican Republic. However, the main maize producing states in 2015 are Sinaloa, Jalisco and Mexico (Figure 5).

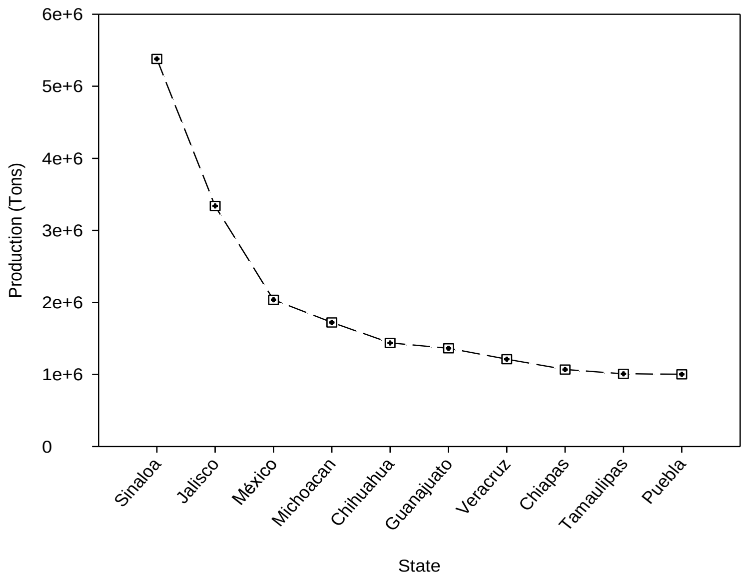

Figure 5. Main maize producing States

The corn price in the national environment is largely influenced by the market supply and demand but also is particularly impacted by the international prices perspectives. The price paid to the producer showed a considerable increase in 2012, due to the drought that affected the United States (Figure 6). Nevertheless, in the last few years a low price is observed, due to the abundant accumulation of inventories in the producing countries.

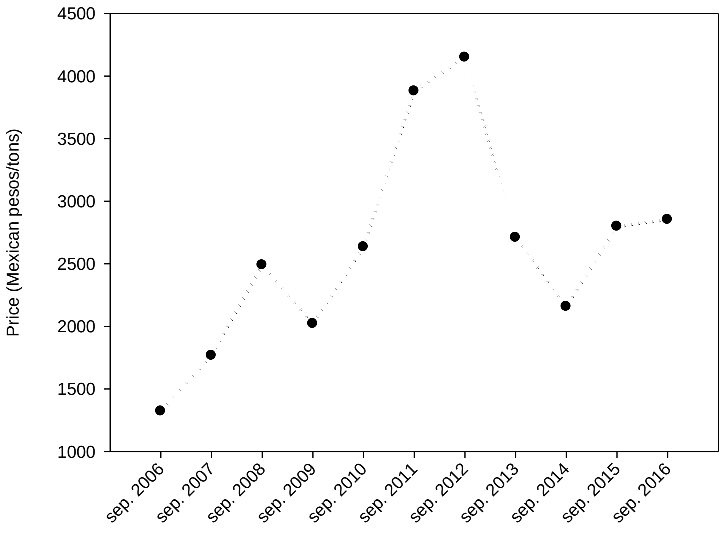

Figure 6. Maize price behavior in Mexico

1.3.2 Maize uses in Mexico

Maize can be used as a human food, feed for cattle, or as a source of a large number of industrial products. According to the production of a wide range of maize varieties, it is possible to generate it is possible to generate a lot of end products through a dry milling process (tortillas, corn flours, dough, pastes, syrups, sweeteners, corn oil, soft drinks, beer) and a wet milling process (sweeteners, dextrose, fructose, glucose, syrups, industrial starch, fibers, ethanol and corn oil from the germ) (Table 1).

Table 1. Maize uses and its varieties

Name of the variety	Uses
Waxy or waxy corn	Useful for the production of adhesives and rubber
Crystalline Maize	As food
Sweet corn	As canned food
Toothed corn	As food in industry
Popcorn	As food
Semi-arid corn	As food for genetic improvement
Truncated corn	For genetic improvement of general maize

Source: Research Center for the Improvement of Maize and Wheat (CIMMY)

1.3.3 Maize genetic improvement in Mexico

Phylogenetic resources are defined as genetic material of plant origin that has a real or potential value for food and agriculture. These resources have been preserved and developed in a traditional way by farmers and are the basis for developing new varieties and technologies. One of the fields of research where international agencies as well as national and private companies have invested more resources is genetic improvement in order to generate new varieties that increase yields and guarantee food security. The development of maize varieties that are better adapted to new climatic conditions is vital for future food production (Challinor et al. 2016). The United Nations Organization mentions that in the developing countries only the average 50% of the area of maize is cultivated with modern varieties, including hybrids and improved free-pollinated varieties, while in developed countries the use of modern varieties is close to 100% (Challinor et al. 2016).

The seed production process of any hybrid or maize-free pollination variety involves the following seed categories:

a) Genetic seed: It is the one that gave origin to the variety, has greater purity, and remains as seed remaining in the store or cold room.
b) Original seed: It is obtained from the genetic seed; its multiplication is usually done in isolated lots in free pollination; it aims to get as many of the parents of the improved variety seed.
c) Basic seed: Obtained from the original seed to obtain higher volumes of seed.
d) Registered seed: It is obtained from the basic seed and is the one sold to the public for the production of certified seed. However, basic seed can also be used in the production of certified seed, but this is more expensive because the volume that is harvested is smaller.
e) Certified seed: It is used by the producer for their commercial crops.

It is important to note that as the process of multiplication of the genetic seed to the recorded one advance the genetic purity of the parents is reduced. Due to the fact that seed multiplication is done in free-pollination lots and (despite being planted in isolated lots of other commercial maize crops) involuntary mechanical or genetic mixtures occur during the seed multiplication process, the seed of the parents can be contaminated. Therefore, it is the responsibility of the Maize Genetic Improvement Program to maintain the genetic purity of the parents to preserve the genetic identity of the variety.

1.3.4 Types of improved maize varieties

It is essential to know the type of improved maize variety that will be produced to be careful in the agronomic management of the production lot. Figure 7 shows the general scheme of genetic improvement.

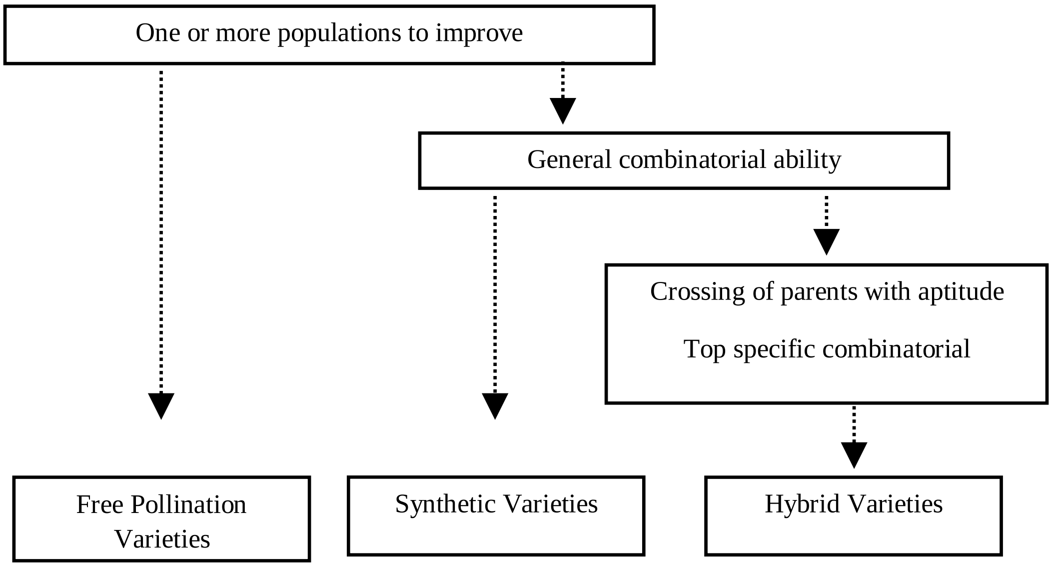

Figure 7. Genetic improvement scheme

Improved maize varieties are classified into three types (Vallejo et al. 2008):

a) Free pollination varieties: They are characterized by having plants with high vigor and in the production of certified seed it is not necessary to plant female and male grooves.
b) Hybrids: They are divided into non-conventional where at least one parent is not an inbred line, and conventional formed with inbred lines.
c) Genetically modified or transgenic hybrids: They are formed with inbred lines in which genes that do not belong to the maize genome were inserted.

Unconventional hybrids are characterized by low phenotypic uniformity and produce less grain yield than conventional hybrids, although it is not a rule because under stress conditions they overcome them; they also have the advantage in seed production that only one or no inbred parent is managed, which reduces the cost of certified seed to the farmer.

They are classified into four categories:

a) Intervarietal hybrids: They are the most common and are formed by the cross of two varieties of free pollination, as is the case of the hybrid HV-313.
b) Family hybrids: They are formed by the cross between two maize families of full brothers or half-brothers who come from the same or different populations.

c) Crossbreed: They are the result of crossing a variety of free pollination or a family with an inbred line.
d) Double mestizo hybrids: They are involved in a simple cross in combination with a variety, a synthetic, a population or a family.

Conventional hybrids are characterized by high phenotypic uniformity and grain yield; they are formed by the cross of two to four inbred lines that in F_1 generation have high heterosis for most of the agronomic traits of economic importance. Conventional hybrids are classified into three categories:

a) Double hybrids: These are formed by four inbred lines; the cross of two of them give rise to the female and the one of the other two to the male. Seven isolated lots are required to form the hybrid. In the production of certified seed, a female: male (H:M) ratio 6:2 is used, because the male is a simple good pollen producer.
b) Trilineal hybrids: They are more uniform than double crosses and are formed by three inbred lines, where two of them form the single female cross and the third is used as a male; five isolated lots are required to form the hybrid. In the production of certified seed, the H:M 4:2 ratio is generally used because the male line has less vigor than a simple cross and therefore not only produces less pollen, but also its production period is shorter.
c) Simple crosses: These have the highest phenotypic uniformity and highest grain yield potential and are used by farmers using high technology. Additionally, simple crosses are formed by two inbred lines, where one of them is the female and the other the male. Three isolated lots are required to form the hybrid. In the production of certified seed, the H: M 4: 2 ratio is generally used, but since the female is an inbred line the agronomic management is more demanding than in the other types of hybrids to achieve high seed yield.

It is important to note that, based on the type of female and male and the H:M ratio used in the production of certified seed, seed yield expected in decreasing order would have the following order: double-trilineal-simple crosses. That is why in the market, the price of certified seed follows the reverse order: simple-trilineal-doubles.

1.3.5 The seed sector in Mexico

The supply of improved maize seeds in Mexico in the period 2009-2010 was 62.55 thousand tonnes. Likewise, the average total quantity demanded of seed in the same period was 160.22 thousand tonnes per year. Of this figure, 68.17 thousand tonnes corresponds to improved seed and 92.05 thousand tonnes to creole seed (J. García & Ramírez, 2014). Seed production is concentrated in the Northwest and Bajio states. Therefore, it is not a coincidence that Jalisco, Michoacán, Sinaloa, Guerrero, and Guanajuato are among the states with the highest consumption of improved seed, states in which the area sown with this type of input is greater than 70% (SIAP, 2016). In contrast, the states with strong rooting of native seeds for planting are Oaxaca, Chiapas, Mexico, and Puebla (Figure 8).

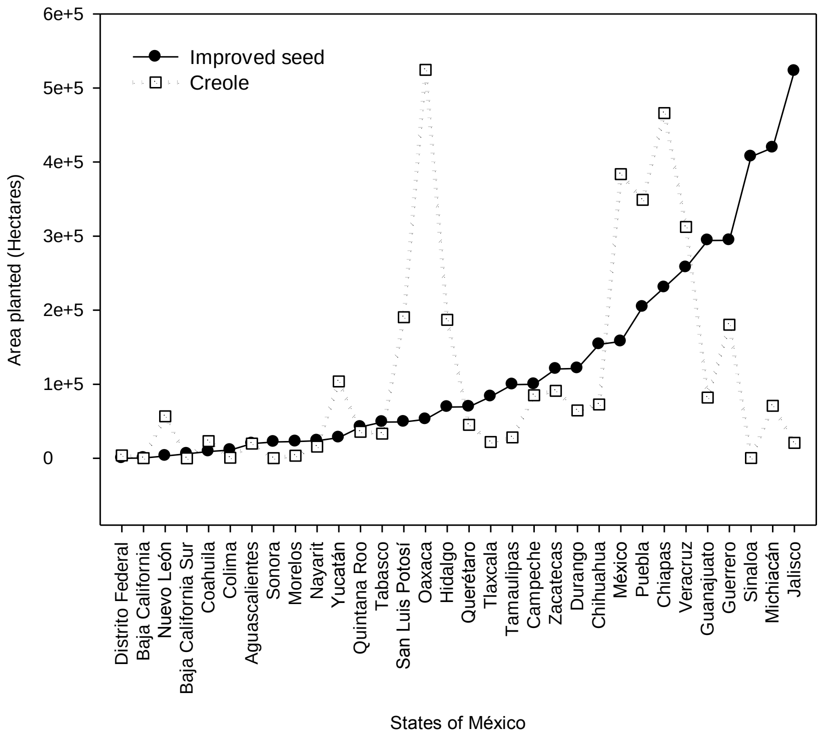

Figure 8. Creole and enhanced seeds used in the different states of Mexico

Seed production in Mexico is in the hands of both the national and international private sector, which participates with 94% of the market, while the public sector maintains 6%. Thirty companies that have greater presence in the seed sector include Bayer-Monsanto, Syngenta Seeds, Sakata Seed of Mexico, Seeds Berentsen, Ahern International of Mexico, Bio International Seed Genetics, Bonnita Seed, Red Gold Seeds, Sea Seed Company, Mexican Conlee Seeds, Colorado River Seeds, Mexico Enhanced Seeds, and Western Seeds.

The trade seeds monopoly has led to the sale prices of the improved seeds in Mexico being the highest in the world. A thousand seeds of corn are traded at US $ 2.7, compared to US $ 1.3 in the United States corn band (Espinosa et al. 2010). For the government, the original seed is produced by the National Institute of Forestry, Agriculture and Livestock Research Postgraduate College, Autonomous Chapingo University, Antonio Narro University, and the International Center for Maize and Wheat Improvement (CIMMYT). The private, public, and social sectors are responsible for multiplying, distributing, and selling it. In addition, the Mexican Association of Seedlings indicates that we offer more than 300 varieties of seeds for the main crops in our country today. The improved seed coverage of INIFAP maize can be seen in Table 2.

Table 2. Outstanding hybrids and pollination varieties in the states of Mexico

States	Outstanding hybrids
Jalisco, Michoacán	H-318 (temporary) and H-377 (irrigation)
State of Mexico, Hidalgo	H-66, H-70 and H49AE
Guerrero, Oaxaca	H-565, H-568
Chiapas	V-231A, V-534, VS-535, V-538C, VS-558, V-559, H-516, H-520, HV-521C, H-560, H-562, H-563
Veracruz	H-520
Tamaulipas and	H-443A

1.3.6 Mexico's commercial opening

Since the 1980s, the Mexican economy has embarked on a deep program of trade liberalization aimed at eliminating external debt problems and striving for sustained and balanced growth.

The incorporation of Mexico into the GATT trade agreements in 1986 and later to those of the WTO signified one of the deeper processes of openness suffered by the Mexican economy, since official reference prices were eliminated, direct controls were replaced by market mechanisms, and the maximum tariff was reduced to 50%. Between 1985 and 1986, about 3,600 tariffs were eliminated, leaving 908, which meant a rapid growth of exports. However, imports also recorded a higher rate of growth, surpassing exports.

With the entry of NAFTA, the percentage share of exports and imports with respect to GDP grew significantly, but the percentage shares of imports in GDP have grown more than exports.

Thereby, the agricultural sector had to adjust promptly to the new rules of the game and answered with strong adjustments in its production structure particularly of basic grains. Within the adjustment process, the maize presented an exceptional situation in the decade of the eighties, as it continued receiving important but declining state support.

Despite the disadvantages of most agricultural production in the face of trade liberalization, the government decided to keep maize out of the liberalization policies to which the other grains were subjected. The protection regime for this grain remained in force until 1994. As a result of these policies and the indiscriminate opening to which the other grains were subjected, there was an intense change in the pattern of maize cultivation, so that between 1990 and 1994 the irrigation regions dedicated to maize doubled. As a result, their share of the total supply in 1994 almost leveled off with the temporary supply. Between 1989 and 1993, grain production grew 80% from 10.9 million tonnes to 18.2 million tonnes; thus, Mexico achieved temporary self-sufficiency in maize. The incorporation of maize into the North American Free Trade Agreement, signed into agreement in 1992, was the preamble to a new shift in public policies for cereals (Saad, 2004).

In the framework of NAFTA negotiations, treaty promoters recognized that giving a green light to subsidized grain imports from the United States would displace hundreds of thousands of small farmers, but it was expected for them to find jobs in industry or urban services. NAFTA stipulated the import tariffs and quotas to which the countries that make up the treaty are subject. With prior knowledge of the sensitivity of some products to the opening, Mexico negotiated with its trading partners the establishment of tariff quotas for certain agricultural products of particular interest and sensitivity for each country (such as maize and beans, among others), which a duty-free import regime was established to cover a certain quota, which, once exceeded, would lead to the collection of high tariffs to be phased out over a period of 15 years until its definitive elimination. In the case of maize and as a highly import sensitive product, a tariff-quota system was established consisting of a tax-free quota of 2.5 million tonnes for the United States and 1,000 tonnes for Canada as of January 1, 1994, which would increase by 3% annually.

Once that quota was exceeded, Mexico could apply a tariff-quota of not less than 30% (Camara de Diputados, 2005). In the case of exceeding quota exports, the importer should pay a base tariff that was set at 215% from January 1994, which for 2008 would be zero. However, during the first ten years of NAFTA, the import quota established for maize from the United States was exceeded eight times without corresponding tariffs being paid, which meant that no more than one tax two thousand seven hundred million dollars was levied.

1.3.7 Federal Government Programs for the cultivation of maize

State intervention in agricultural markets has been present since 1937, through the creation of various regulatory and subsistence committees as well as national distribution, export, and import companies. The National Company of Popular Subsistence (CONASUPO), created in 1965, served as an intermediary between national and international markets in the same way established official purchase prices for grains, called guarantee prices, were also responsible for importing in case of deficit and exporting when necessary. Additionally, they were also responsible for promoting the industrialization of agricultural crops necessary for food as well.

In its beginnings, the company bought large quantities of grains, since the excess of supply pushed the prices of the grains down and many producers chose to sell to the company; as a result of this, the company kept fixed guarantee prices for a decade, discouraging production.

Maintaining fixed guarantee prices during the first few years after the excessive purchases helped to balance supply and demand, but maintaining fixed prices for a decade led to a large deficit in traded grains, and large quantities of grains were imported in the early 1980s.

It is considered that from 1987, CONASUPO presents a gradual retirement of the agricultural markets, given the adoption of the new development model in Mexico. Thus, in 1999, the company was no longer significant in the maize, beans and milk powder markets, so the Secretary of Agriculture, Livestock and Rural Development opted to dismantle the company on December 31 of that same year (García et al. 2003).

In 1991 the Support and Services to Commercialization Unit (ASERCA) was created with the purpose of having an agency that promotes the commercialization of agricultural production for the benefit of Mexican farmers in the face of international trade openness. At the beginning, the dependence was responsible for promoting the marketing, export promotion, development of mechanisms, and negotiation schemes design as well as the use of hedges of price risks. Since 1993, it has been entrusted to operate and manage the Direct Field Support Program (PROCAMPO).

In 1996, ASERCA developed the register of plots, surfaces, and producers, providing direct support to the field and mediated negotiations between producers and buyers. Subsequently in 2001, the dependence ceased to take care of the issues related to foreign agricultural trade. Finally, in 2012, the Agency for the Marketing and Development of Agricultural Markets was established as a decentralized administrative body. In this sense, ASERCA has controlled the distribution of the main subsidies granted to domestic producers, and has also been in charge of the preparation and dissemination of various bulletins on markets and agricultural prices.

The Direct Field Support Program (PROCAMPO) replaces the guarantee price scheme at the end of 1993. Nowadays, it can be considered the most important program of support to agricultural producers in the country. The program support unit is the area sown and not the volume sold as in the scheme of guarantee prices. It is known that PROCAMPO is used as an instrument to support domestic producers, and to compensate, in some way, the subsidies granted to producers from other countries with which they compete at the international level. Initially the program was directed only at the hectares that planted cotton, rice, safflower, barley, beans, maize, sorghum, soybeans, and wheat; subsequently, the coverage of the program was sold to any other legal crop.

In the beginning, it was suggested that the duration of the program would be fifteen years, culminating in 2008 (the same year in which tariffs were not imposed on maize imports). In order to complement and improve the operation of the program, this has been modified and has been added slopes such as PROCAMPO Capitalize, which was established in 2002. Through this scheme, financing is authorized to the beneficiaries to capitalize their production units, develop productive projects, and modernize its infrastructure.

Subsequently, the denominations of the program are changed to Program PROCAMPO to Live Better in 2010, Component PROCAMPO to Live Better in 2011, and PROCAMPO Productive in the year 2013. However, the most important change in recent months is the transformation to PROAGRO Productive. The objectives have been the same over the last twenty years; however, there is now a closer monitoring of the support destination, since the beneficiaries must declare how they will invest the amount granted. Despite the changes that the program has undergone, it is recognized that it is one of the most important in Mexican agriculture, supporting approximately 2.8 million producers; furthermore, almost all of the main crops of the country are planted on a subsidized surface (ASERCA, 2012).

1.4 References

ASERCA. (2012). Boletín informativo no. 226. http://www.infoaserca.gob.mx/claridades/marcos.asp?numero=226.

Bellon, M. R. (1991). The ethnoecology of maize variety management: A case study from Mexico. *Human Ecology,* 19(3): 389–418.

Birol, E., Smale, M., Gyovai, A. (2006). Using a Choice Experiment to Estimate Farmers' Valuation of Agrobiodiversity on Hungarian Small Farms. *Environmental & Resource Economics,* 34: 439–469.

Birol, E., Villalba, E., Smale, M. (2009). Farmer preferences for milpa diversity and genetically modified maize in Mexico: a latent class approach. *Environment and Development Economics,* 14(04): 521–540.

Bongaarts, J. (1996). Population Pressure and the Food Supply System in the Developing World. *Population and Development Review,* 22(3): 483. doi:10.2307/2137717

Camara de Diputados, LIX Legislatura. (2005). El sistema de cupos y los subsidios para el maíz blanco y el frijol en el marco del TLCAN y su efecto en las relaciones comerciales de los países signatarios. México.

Castillo, J., Chávez, C. (2013). Caracterización campesina del manejo y uso de la diervisad de maíces en San Felipe del Progreso, estado de México, 10(1): 23–38.

Challinor, J., Koehler, K., Ramirez-Villegas, J., Whitfield, S., Das, B. (2016). Current warming will reduce yields unless maize breeding and seed systems adapt immediately. *Nature Climate Change,* 6(10): 954–958. doi:10.1038/nclimate3061

CIMMYT. (1993). La adopción de tecnologías: Guía para el diseño de encuestas. (C. P. de Economía., Ed.). D.F. México. 88 p.

Espinosa, A., Tadeo, M., Turrent, A. (2010). Concentración de la oferta de semillas mejoradas de maíz. La jornada del campo, (30 suplemento).

FAOSTAT. (2016). Organización de las naciones unidas para la alimentación y la agricultura (FAO). Accessed July 2016, available at http://faostat.fao.org. doi:Accessed July 2016, available at http://faostat.fao.org

García, J., Ramírez, R. (2014). El mercado de la semilla mejorada de maíz (Zea mays L.) en México: análisis del saldo comercial por entidad federativa. *Revista*

Fitotecnia Mexicana, 37(1): 69–77.

García, R., García, A., García, R. (2003). Teoría del mercado de productos agrícolas. Montecillo, México. (No. 380.141 G3.).

Gobierno de México. (2015). 4to. Informe de Gobierno 2015-2016. México: Gobierno Federal Mexicano. Accessed July 2016, available athttps://www.gob.mx/informe

Harrison, P. (2002). Agricultura mundial: hacia los años 2015/2030. Dirección de Información de la FAO. Retrieved January 20, 2017, from http://www.fao.org/docrep/004/y3557s/y3557s06.htm

Hellyer, E., Fraser, I., Haddock-Fraser, J. (2012). Food choice, health information and functional ingredients: An experimental auction employing bread. *Food Policy*, 37(3): 232–245.

Herrera, E., Macías, A., Díaz, R., Valadez, M., Delgado, A. (2002). Uso de semilla criolla y caracteres de mazorca para la selección de semilla de maíz en México. *Rev. Fitotecnia Mexicana,* 25(1): 17–23.

INEGI. (2015). Encuesta Nacional Agropecuaria ENA 2014. Resultados. http://www.inegi.org.mx/est/contenidos/proyectos/encuestas/agropecuarias/ena/ena2014/doc/pre sentacion/ena2014_pres.pdf. (Accessed July 2016). Retrieved from Accessed July 2016, available at http://www.inegi.org.mx/est/contenidos/proyectos/encuestas/agropecuarias/ena/ena2014/doc/pre sentacion/ena2014_pres.pdf.

INEGI. (2016). México en Cifras. Información Nacional, por Entidad Federativa y Municipios. Accessed July 2016. Retrieved from http://www.inegi.org.mx/

Martínez, B., Vallejo, J. (2011). Las nuevas realciones rural-urbanas mercados de trabajo en Morelos y el Estado de México. Nuevas Ruralidades. Expresiones de la transformación social en México. Ed. UNAM, Instituto de Investigaciones Antropológicas. México, DF.

Menéndez, C., Palacio, V. (2015). Pobreza y seguridad alimentaria en México y Estados Unidos: 2000 - 2010. *CIMEXUS*, 9(1): 13–30.

Morris, L., Bellon, M. (2004). Participatory plant breeding research: Opportunities and challenges for the international crop improvement system. *Euphytica*, 136(1): 21–35.

Saad, I. (2004). Maíz y libre comercio en México. *Claridades Agropecuarias.* 127:44-48.

SAGARPA. (2015). Secretaría de Agricultura, Ganadería, Desarrollo Rural, Pesca y Alimentación. Gobierno Federal. Retrieved February 3, 2016, from http://www.gob.mx/sagarpa

Sandoval, E., Sanchez, J., Padilla, J., Avendaño, A., Arellano, L., Gonzalez, T. (2014).

Sector semillas de México : problemática y alternativas. (Universidad de Guadalajara, Ed.). Guadalajara, México. 144 p.

SIAP. (2016). Avances de Siembras y Cosechas por Estado y Año Agrícola. Secretaría de Agricultura, Ganadería, Desarrollo Rural, Pesca y Alimentación. Accessed March 2016. http://www.gob.mx/siap/

Sibiya, J., Tongoona, P., Derera, J., Makandaa, I. (2013). Farmers' desired traits and selection criteria for maize varieties and their implications for maize breeding: A case study from Kwazulu-Natal Province, South Africa. *Journal of Agriculture and Rural Development in the Tropics and Subtropics,* 114(1): 39–49.

Vallejo, H., Ramírez, J., Chuela, M., Ramírez, R. (2008). Manual de Producción de Semilla de Maíz. Estudio de Caso. Folleto Técnico Núm. 14. Campo Experimental Uruapan. INIFAP, CIRPAC. Guadalajara, Jalisco, México. 96 p.

Wise, A. (2008). Estado de emergencia para el maíz mexicano: Proteger la agrobiodiversidad apuntlando a la economía campesina. J. Luis Seefoó Luján (Ed.) El Colegio de Michoacan: Mexico, 167-198p.

FIRST PAPER: THE IMPORTANCE OF FARMERS´ SOCIAL, ENVIRONMENTAL AND ECONOMIC OBJECTIVES FOR THE ADOPTION OF IMPROVED CORN SEEDS IN CHIAPAS, MEXICO

ACCEPTED: REVISTA DE LA FACULTAD DE CIENCIAS AGRARIAS

CHAPTER 2

THE IMPORTANCE OF FARMERS´ SOCIAL, ENVIRONMENTAL AND ECONOMIC OBJECTIVES FOR THE ADOPTION OF IMPROVED CORN SEEDS IN CHIAPAS, MEXICO

While improved seeds can increase performance and productivity of corn in Mexico, its adoption remains low. In order to understand the behavior of adoption of technological innovations, it is necessary to understand the heterogeneity of farmers taking into account not only their socio-economic characteristics and the nature of their holdings, but also their opinions, attitudes, preferences and objectives. Therefore, in this investigation our aim was firstly to analyze the objectives that farmers have to take into account when they cultivate corn in Chiapas and we have used the analytic hierarchy process. Secondly, to segment the farmers based on their opinions, attitudes and risk aversion using the cluster analysis and observing the heterogeneity by the TOBIT analysis. Data were collected through a sample of 200 maize farmers in Chiapas, Mexico. Three segments of farmers were identified: In “transition" — not fully appreciating the potential of improved seeds (52.5%); “conservative" — with a negative perception of improved seeds (18.5%); and “innovative" — with a positive perception (29%). It was observed that the objectives of farmers are different for each segment.

2.1 Introduction and Objectives

Chiapas is the Mexican state that holds the highest rate of maize production (690 millions of tonnes). Nevertheless, it also holds the lowest yields (1.6 tha^{-1}) (SIAP, 2016). This low productivity is due to several factors being one of them the use of Creole seeds which, in spite of being adapted to unfavorable environmental conditions, have a low productive potential and are more likely to suffer diseases reducing the crop's quality and productivity. For that matter, the use of improved maize seeds entails an opportunity of technological improvement which would imply raising both the performance and the profitability of maize farms (García and Guzmán, 2015). If we want to increase the use of improved seeds it is necessary to take into account the huge heterogeneity of existing farmers with specific differentiating circumstances which, on the other hand, condition the farmers' production decisions. Among these circumstances we can underscore the context, natural and economic factors, business objectives, farmers' preferences and the limitations in available resources.

If the technologies suit the specific circumstances of the farmers, these will adopt them quickly (CIMMYT, 1993). Therefore, if we want to understand the behavior of the adoption of technologies in this sector, it is necessary to understand the heterogeneity of the farmers taking into account not only their socioeconomic characteristics and those of their farms but also their attitudes and their preferences of the perceived risk concerning the improved seeds. Likewise, it is important to include in this analysis the objectives of each farmer in his decision to manage the farm. Therefore, the purpose of this article is to provide some technical, socioeconomic and typological information of maize farmers in the state of Chiapas which could help to boost some differentiated strategies of adoption of such an important crop in the state.

The Principal Components Analysis (PCA) was used to capture and to simplify the attitudes and preferences. The results were used as farmers' variables of segmentation through a Cluster Analysis (CA). Moreover, the Analytic Hierarchy Process (AHP) was used to analyze the objectives. The AHP method is a technique that fits into the spectrum of discreet multicriteria decision techniques. Therefore, the basic concepts of AHP rely on the theoretical foundation and on the common terminology of the Theory of Multicriteria Decision (TMCD) (Bellon and Risopoulos, 2001).

The multicriteria decision making is characterized by the existence of more than one criterion to determine the achievement of a predetermined objective. Moreover, the

Tobit econometric model made possible to analyze the heterogeneity of the farmers' objectives concerning their sociodemographic variables.

2.2 Methodology

2.2.1 Study Area

Chiapas is located in the south-eastern tip of Mexico, bordering Tabasco in the North, Veracruz and Oaxaca in the West, the Pacific Ocean in the South and the Republic of Guatemala in the East. It has an area of 74,415 km^2 (Figure 9).

Figure 9. State of Chiapas location

Farming represents 8% of the gross domestic product of Chiapas and it generates employment for 40% of its economically active population (INEGI, 2015). This region generates great surpluses of maize which is destined to other parts of Mexico but it is still dominated by small-scale farmers who produce for the market and for self-consumption. Nowadays 696,000 hectares of maize are planted out of which only 240,629 hectares are sown with improved seeds (SIAP, 2016). The average yield is 1.6 tha^{-1} and traditionally this crop constitutes the diet of the inhabitants. Its planting is linked with a number of cultural, sociopolitical and economic phenomena since it entails food security and employment for 3 out of 5 farmers of its land (Fundación Produce Chiapas, 2011).

2.2.2 Definition of Sample Size

The data analyzed comes from a personal face-to-face survey carried out between January and March of 2015 and a sample of 200 farmers who were stratified by the size of the farm and by the seed variety that was used. The surveys were conducted in an area of potential production of maize in the state of Chiapas: Villaflores, Chiapas de Corzo, Villacorzo and La Concordia (Production >54,000 tonnes a year CEIEG, 2015). In order to calculate the sample size, they surveyed the farmers that signed up in the Program of Direct Helps to the Farm (PROCAMPO) in the aforementioned towns. The farmers that signed up in the program represent 98% of all farmers according to SAGARPA (2015). The sample size was calculated based on a formula of finite populations with a significance level (α) of 5% (Z=1.96) and a maximum level of error of 6.87% (Rojas, 2005). The methodological focus followed in this study is better explained in the following scheme.

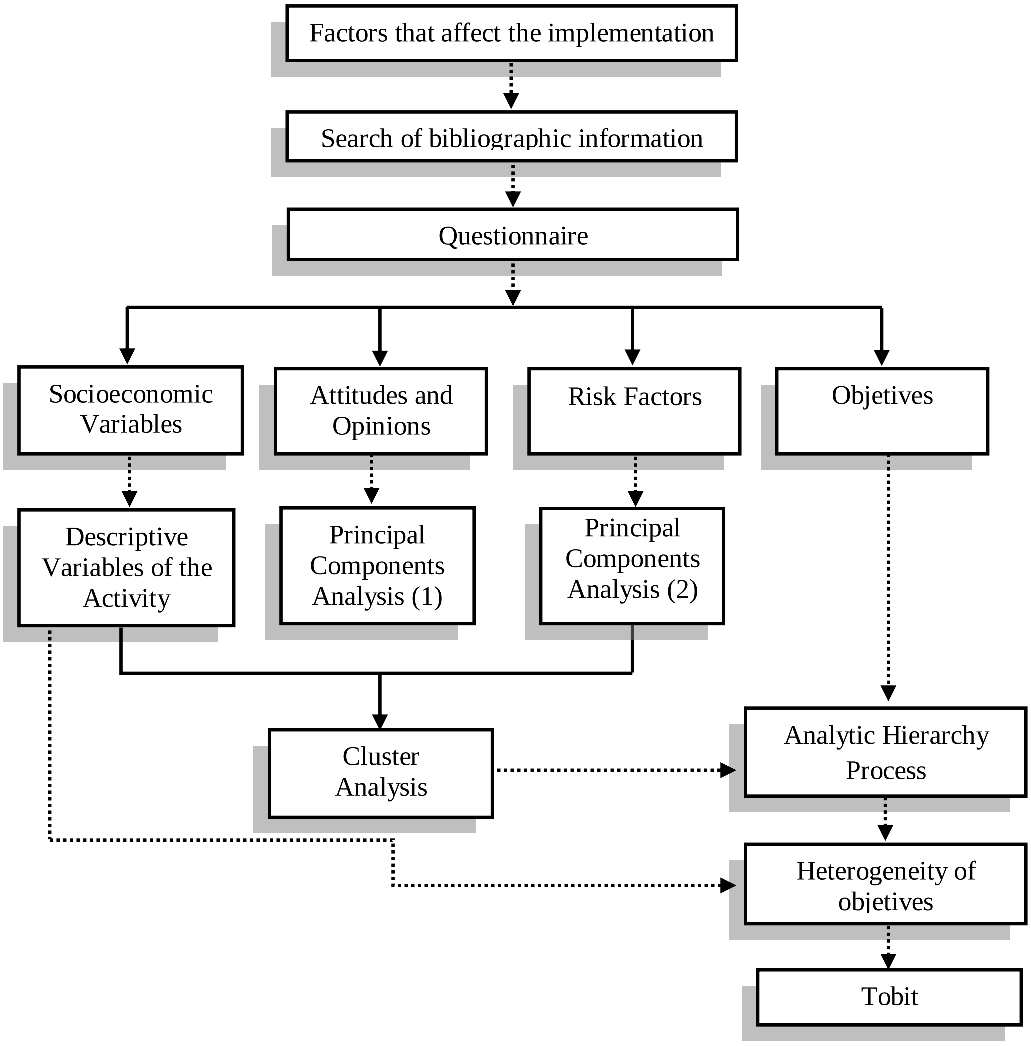

Figure 10. Methodological research scheme

The survey allowed to delimit, to gather and to systematize most of the analyzed data in the research. For this purpose, a closed 54-question questionnaire was applied to each farmer which was checked before its final application. The variables that were analyzed in the questionnaire were divided into the following sections complying with the classification presented by Kallas et al. (2010) and Knowler and Bradshaw (2007): farmer characteristics, farm structure, farm economic data concerning the maize crop, external factors, attitudes and opinions of the farmer concerning the adoption of new technologies (particularly improved seeds) in the farm, the risk perceptions of such adoption and finally the economic, sociocultural and environmental objectives of each farmer. The attitudes, opinions and risk perceptions which play an important role as determining factors in the adoption of improved seeds (Blanco and Bardomás, 2015; Cavallo et al. 2014; Ceballos and López, 2003) were presented in different constructs including several items measured in a Likert scale from 0 to 10, where 0 indicated that the farmer was not at all in agreement with the claims submitted and 10 where he was in total agreement. Identified statements were discussed and analyzed in a discussion group composed by different researchers involved in the study. The construct of the variables used for the analysis is presented in Table 3.

Table 3. Variables on attitudes, opinions and risk preferences used in the study

Attitudinal variables	*Name of the variable*	*References*
The sale of improved maize prices to cover the higher production costs	(a_1)	(Valdivia et al. 2015)
Planting corn with improved seeds can ensure the future of farms	(a_2)	(Valdivia et al. 2007)
Seeding with improved maize seeds contributes to a positive image for the exploitation	(a_3)	(Valdivia et al. 2007)
Planting improved seeds with increased household income	(a_4)	(Hellin and Bellon, 2007)
Improved maize seeds have better market acceptance	(a_5)	(Hellin and Bellon 2007)
The masa-tortilla relationship is greater with the improved seeds	(a_6)	(Salazar et al. 2015)
Risk variables		
Risk from marketing is less with improved seeds	(b_1)	(Birol et al. 2012)
The risks from proliferation of pests and diseases are lower with improved seeds	(b_2)	(Li et al. 2012; Smale et al. 1994)
There is less risk for lending to farmers with improved seeds	(b_3)	(Li et al. 2012; Smale et al. 1994)
The risk from fluctuation is lower yields improved seeds	(b_4)	(Sibiya et al. 2013; Veisi et al. 2016)
The risk from drought is less with improved seeds	(b_5)	(Veisi et al. 2016; Asrat et al. 2010; Kamara et al. 2006)
The risk of losses due to frost is less with improved seeds	(b_6)	(Asrat et al. 2010; Veisi et al. 2016)

As a third key element in the process of adoption, we have stressed the importance of the typical objectives of each farmer when it comes to planning their agricultural activities (Kallas et al. 2010). Those objectives were classified in economic, sociocultural and environmental objectives (Peng et al. 2015). Within each primary objective the farmers also had some secondary objectives. The secondary economic objectives were: to maximize the maize sales, to maximize the family's total earnings and to maximize earnings of the maize crop. The secondary sociocultural objectives included: to generate jobs in the area, to avoid the depopulation of the rural environment and to keep the existing sociocultural values. The secondary environmental objectives were: to foster agricultural practices which would respect the environment, to keep the soil's fertility and to maintain the Creole races of maize. All the aforementioned objectives were defined according to an agricultural consultant's board in the area of Chiapas and discussed in a discussion group made up of researchers belonging to the National Institute for Forestry, Agriculture and Livestock Research. In order to determine the relative importance of each objective the methodology of the Analytic Hierarchy Process (AHP) was used, a 1-9 scale technique which allows through the use of pair-wise ranking between two elements the identification of the prioritization of each farmer towards each analyzed objective (Saaty and Vargas, 1984).

The factors that represent the opinions, attitudes and risk perceptions identified with the PCA were used as the farmer's segmenting variables through a Cluster Analysis (CA). Therefore, with the segments and the relative importance of the objectives studied in the AHP it was possible to characterize and to identify the different existing profiles concerning the adoption of improved seeds. The analyses were carried out through the SPSS Statistics 21 Program.

To assume homogeneity of the farmers with respect to their economic, sociocultural and environmental objectives is not very realistic due to the heterogeneous nature of the farming decision maker (Guillem et al. 2015). Therefore, this study has considered as equally relevant to analyze the heterogeneity of the farmers' objectives taking into account the socioeconomic variables gathered (Table 3). The Tobil model has been used due to the character of the dependent variable (relative importance censored between 0% and 100%) using the STATA 12 program.

Table 4. Variables used in the TOBIT model

Variables	Acronym	Coding
Members-of-household	V1	Number of members in the household (Continued)
No schooling	V2	No studies (0: No, 1: Yes)
Low level of education	V3	Primary not completed (0: No, 1: Yes)
Mid-level education	V4	Secondary completed (0: No, 1: Yes)
Family member with university education	V5	Number of family member with university education (0: No, 1: Yes)
Generations dedicated to farming	V6	Number of generations in agriculture (Continued)
Main source of information	V7	Information from employees (0: No, 1: Yes
Lack of organization of the Maize productive system	V8	Organization by the Corn Product System (0: No, 1: Yes)
Holdings owner	V9	If the farmer interviewed is the owner of the plot (0: No, 1: Yes)
Tenure	V10	If the plot is small property (0: No, 1: Yes)
Number of hectares	V11	Number of hectares planted with corn (Continued)
Yield	V12	Tonnes per ha
Sales	V13	Sales of corn in Mexican pesos (Continued)
Potential for acceptance of improved maize seeds	V14	PCA results
Low risk aversion	V15	Resultado del PCA

2.3 The Analytic Hierarchy Process (AHP)

According to De Cock (2005), in the process of adoption of a technology individuals don't optimize their decisions based on a sole criterion but, on the contrary, they aim at finding a balance or a compromise between a set of criteria or objectives. Therefore, in order to obtain the priorities that an individual assign to a set of elements based on appraisals assigned to them according to his judgments and preferences, it is necessary to establish a set of procedures which would allow to make use of the power of the mind to connect the experiences and the intuitions with the objectives that have been set (Moreno, 2002).

The AHP is a flexible and highly theoretical technique which allows the resolution of problems with multiple criteria, objectives and the inclusion of risk and uncertainty. Moreover, it can adapt to any type of economic and territorial environment

(Hernández and Cardells, 1999). The AHP method has been used with great success in a wide range of applications in diverse fields such as the protection of natural spaces and the environmental assessment (Cabrera et al. 2014). It has been successfully used in farming to evaluate ways of farming which are an alternative to conventional farming (Requena and López, 2005; Xu and Zhang, 2009), in the analysis of adoption (Kallas et al. 2010), the preferences of feeding (Kallas and Gil, 2012), the assessment of agricultural multifunctionality (Kallas and Gómez-Limón, 2007), the selection of irrigation systems and farming technology (García et al. 2005; Karami, 2006), in the assessment of different farming systems for the production of olive fields (Parra et al. 2008), to determine the suitability of farmlands (Ceballos and López, 2003), in aspects relating to the PCA (Gómez-Limón and Atance, 2004), to analyze farmers' risk factors (Valdivia et al. 2007), in credit evaluations (Xu and Zhabg, 2009), in the assessment of public policies (Gerber et al. 2008), in the development of new products (Chin et al. 2008) and in the evaluation and selection of management systems for productive areas (Parra et al. 2008), among other applications.

2.3.1 Basic concepts and operational phases of the AHP

The Analytic Hierarchy Process (AHP) is a multi-attribute technique for decision making. The purpose of this technique is to break down a complex problem into hierarchies where each level is disaggregated in specific elements (Saaty and Vargas, 1984).

The first thing to do in the AHP methodology is fixing the main objective or goal that one is intending to achieve. Nevertheless, in order to reach the main objective it might be required to achieve some other more specific (secondary) objectives in which the main objective can be broken down. Once the hierarchy tree is built with its different objectives, we would have to assess the different alternatives with respect to each of the nodes on which they directly depend, and these with respect to the nodes belonging to the level immediately superior in the hierarchy, and so on until achieving the main objective or goal.

For that matter, what first of all needs to be done is carrying out an estimation of the priorities, weightings or local weights (w) of the sub-nodes regarding their father node. This procedure consists in making comparisons by pairs of the different sub-nodes, establishing in this way the ratios that correspond to the relative importance of the sub-nodes considered in each comparison.

In this way, it is possible to generate in each case a matrix called "Saaty matrix" or matrix of assessment for each individual k which presents the following structure:

$$A_k = \begin{bmatrix} a_{11k} & a_{12k} & \cdots & a_{1nk} \\ a_{21k} & a_{22k} & \cdots & a_{2nk} \\ \cdots & \cdots & a_{ijk} & \cdots \\ a_{n1k} & a_{n2k} & \cdots & a_{nnk} \end{bmatrix}$$

Where a_{ijk} represents the comparison value (reason) between the sub-node i and the sub-node j; that is the number of times that sub-node i satisfies better than sub-node j the objective set by the node father.

Subsequently, the RGMM method or the geometric mean method was applied to calculate the weights' vector ($\hat{w}_{ik}$) (Saaty, 1980). This means that, in accordance with the Saaty matrix ($\hat{A}_k$), the weights of each sub-node are calculated by using the geometric mean of their corresponding judgements ($\hat{a}_{ijk}$). In this algebraic way, each priority is calculated in the following way: $\hat{w}_{ik} = \sqrt[n]{\prod_{i=1}^{i=n} \hat{a}_{ijk}} \quad \forall \quad i, j \in n$.

Where $\hat{w}_{ik}$: Weight or priority of sub-node i for the decision maker k, $\hat{a}_{ijk}$: Judgements or comparison values expressed for the sub-node i concerning sub-node j, n: total number of sub-nodes to be compared.

After having made the pair-wise comparisons between different objectives and since we have their corresponding local weights, these are tied together with the main objective of the hierarchy. For that purpose, the local weights calculated are transformed into global weights. In order to aggregate $\hat{w}_{ik}$ weighings and to obtain those of the ($\hat{w}_i$) group we have used the geometric mean because this is the most recommended method for the group decisions in the social field (Forman and Peniwati, 1998). Aczél and Saaty (1983) and Aczél and Alsina (1986) propose an aggregated Saaty matrix $(\hat{A} = \hat{a}_{ij} = \sqrt[m]{\prod_{k=1}^{k=m} \hat{a}_{ijk}})$ from which we obtain the weights' vector of the different criteria that are representative of the entire group together ($\hat{w}_i$).

2.4 Results and Discussion

2.4.1 Attitudes, Opinions and Risk Preferences

As we have already expressed, the PCA was carried out to analyze the farmers' attitudes, opinions and risk perceptions towards the improved seeds. In both cases there was only one factor (Table 5).

Table 5. Results from PCA on farmers' attitudes, opinions and perceptions

Variables	Confirmatory factor: Potential acceptance of improved corn seeds
The sale of improved maize prices to cover the higher production costs	0.85
Planting corn with improved seeds can ensure the future of farms	0.84
Seeding with improved maize seeds contributes to a positive image for the exploitation	0.83
Planting improved seeds with increased household income	0.82
Improved maize seeds have better market acceptance	0.81
The masa-tortilla relationship is greater with the improved seeds	0.77
Cronbach' Alfa: 0.882, KMO: 0.839, Bartrlet Test: 774.32 (0.000, explained variance: 68%, rotation method: Varimax	

Variables	Confirmatory factor: Risk aversion
Risk from marketing is less with improved seeds	0.87
The risks from proliferation of pests and diseases are lower with improved seeds	0.82
There is less risk for lending to farmers with improved seeds	0.81
The risk from fluctuation is lower yields improved seeds	0.79
The risk from drought is less with improved seeds	0.78
The risk of losses due to frost is less with improved seeds	0.21
Cronbach' Alpha: 0.795, KMO: 0.767, Bartrlet Test: 613.85 (0.000), explained variance: 56%, rotation method: Varimax	

2.4.2 Farmers' Segmentation

Starting from the confirming factors that were previously extracted, the farmers were segmented. The result of the application of the Cluster Analysis (CA) was collecting clusters.

The first segment called "transitional farmers" is the biggest in size and it represents 52.5% of the sample. This group does not fully assess the potential of the improved seeds despite the fact that a large number of the members of this group use them

(54.7%). They have an average age of 58 years, the sown area is 4.7 hectares with a yield of 3.7 tha^{-1} and they use 89.6% of maize production for sale. Generally they are farmers who assume risks in their management and who are in the phase where they are analyzing the technical and economic aspects of the innovation (Young et al. 2001). Therefore, learning the new technology is important because it reduces uncertainty and it improves decision making. Before carrying out a judgment, the farmers have preconceived ideas about the economic benefits of the new technology. Based on the information generated, the farmer checks his subjective beliefs concerning the profitability of the technology and he decides whether he goes or does not go ahead with the technology (Ghadim et al. 2005).

The second segment identified as "conservatives" represents 18.2% of the simple. In general, they show a negative attitude towards improved seeds. This group has an average age of 60 years, the sown area is 3.4 hectares with a yield of 2.9 tha^{-1} and they use 82.5% of maize production for sale and their income comes mainly from maize (92.8%). They mention that there are factors which restrict their use and they are characterized by the lack of economic resources and very limited machinery and technical assistance available to them. This data coincides with what Feder et al. (1985) says about the factors that are necessary for the adoption of an efficient technology. They are farmers who are reluctant to risk and who don't apply immediately the technology transferred to them but they rather wait for another farmer to do it first (late adopters) (Rogers, 1986). Generally, they don't trust in farming practices which are different from what they have traditionally been applying in the past, something pretty similar to what was found out by Rivera and Romero (2003). These farmers prefer to cultivate the Creole variety in order to stay in the productive system mainly because of its flavor, the recycling of seeds and the early ripening. This coincides with what Magorokosho (2006) says about the local varieties harvested in Malawi, Zambia and Zimbabwe. Altogether, some research studies (Córdova et al. 2002) show that the farmers located in isolated production areas and in slopes with poor soils generally don't have access to improved seeds either because they have not access to credit or because the seed industry is not interested in those areas that generate very little profit.

Likewise, the source of information used in this segment of farmers is the members of their families. For this reason it is necessary to diversify their sources of information and to experiment in order to appreciate the benefits of the improved seeds (Lee, 2005). Ignorance lies at the root of the difference observed between experimental performance and that achieved by most of the farmers (Galindo, 2007).

Conventional farmers sow the traditional milpa. The milpa is an agroecosystem characterized by the polyculture. The seeds of maize, bean and pumpkin that the farmers sow every year are surrounded by weeds (quelites among others) which they let grow and which they cut off in several occasions during the process of growth of the maize and the bean. This way of farming can be more productive because they measure not only a crop's yield but the production of different species that are used for a balanced diet and as a system that maintains the quality of the soil. Likewise, native races have more benefits other than the yield such as their polyculture uses and the lower costs in the use of inputs (Turrent et al. 2012).

Hellin and Keleman (2013) state that the farmers make the deliberate decision of not adopting improved varieties. Creole varieties can be focused on markets that are specialized in maize with a very well defined market niche. These can also improve the income and they can offer opportunities to Mexican farmers. These value chains allow the farmers to generate greater income and to keep the varieties of Creole maize in situ.

The third segment is called "innovators" and is made up of 29% of the sample. The members of this group use improved seeds and have a positive perception of them. The age of this group of farmers is 52 years. They have a greater sown area (5.2 hectares) and a better yield (4.2 tha^{-1}). Nevertheless, studies carried out by the National Institute for Forestry, Agriculture and Livestock Research in Chiapas have shown yields of 15 tha^{-1} with improved hybrids (Coutiño et al. 2004). Also, 93.5% of its production is used for sale and the crop's percentage of income is 86.03%. These farmers are cautious with regard to risk and most of them are users themselves (34.9%). In the same way, they have the highest income which coincides with Chirwa (2005) who states that the adoption is positively associated with greater levels of education, bigger size of fields and higher income.

The data indicate that the farmers observe agronomic and economic advantages, and this is a signal that indeed they are motivated to use improved seeds. The most important advantages that the farmers consider have to do with greater yields and with resistance to flattening. Nevertheless, in order to improve maize productivity, the technological adoption must start from a whole set of technologies and not only from one technological component. Consequently, if farmers adopt only the use of improved varieties instead of a package that includes the application of fertilizers, better sowing methods and management practices, the results will not have an effect on the crop's productivity (Karanja et al. 2003).

2.4.3 The Farmers' Objectives

Once the different segments were identified, it was time to assess the main objectives that the farmers take as a reference in order to guide their farms through the AHP methodology. These results suggest that for transitional farmers the economic objectives are the most important with an accumulated weight of 63.50%, followed by environmental objectives (22.32%) and sociocultural (14.18%). This hierarchy of objectives is also applicable to the conservatives and innovators groups. We have seen that transitional farmers have a greater interest in economic objectives; the conservatives are more interested in sociocultural objectives; and the innovators are more interested in environmental objectives (Table 6).

The results of the weighing of secondary objectives show that transitional farmers have a greater focus on maximizing sales, generating jobs in the area and maintaining the soil fertility. The conservative farmers give more importance to maximizing the overall benefits of the family, avoiding the depopulation of the rural environment and maintaining the soil fertility.

The innovators are interested in maximizing the benefits of the maize crop, generating jobs in the area and fostering farming practices that respect the environment (Table 6). In general terms, the least important objective of the segments is keeping the existing sociocultural values, and the most important is maximizing sales (Figure 11).

Table 6. Results of the hierarchical structure of farmers' objectives according to the group

Farmers' Objectives	C1	C2	C3
Economic (wo_1)	**63,50%[a]**	**51,16%[b]**	**48,46%[b]**
$wo_{1.1}$: To maximize sales	49,77%[a]	29,80%	38,02%[ab]
$wo_{1.2}$: To maximize the overall benefits of the family	19,65 %[b]	40,08%[a]	20,02%[b]
$wo_{1.3}$: To maximize the benefits of the maize crop	30,58%[b]	30,11%[b]	41,96%
Sociocultural (wo_2)	**14,18%[ab]**	**21,09%[a]**	**12,67%[b]**
$wo_{2.1}$: To generate jobs in the area	52,96%[a]	29,51%[b]	49,40%[a]
$wo_{2.2}$: To avoid the depopulation of rural environment	27,64%[b]	45,55%[a]	32,93%[b]
$wo_{2.3}$: To keep the existing sociocultural values	19,40%[a]	24,94%[a]	17,67%[a]
Environmental (wo_3)	**22,32%[b]**	**27,75%[b]**	**38,88%[a]**
$wo_{3.1}$: To foster farming practices that respect the environment	21,30%[b]	22,15 %[b]	39,92%[a]
$wo_{3.2}$: To maintain the soil fertility	53,87%[ab]	57,13%[a]	41,80%[b]
$wo_{3.3}$: To maintain the Creole races of maize	24,83%[a]	20,72%[a]	18,27%[a]

C1:In transition; C2:Conservative; C3:Innovative

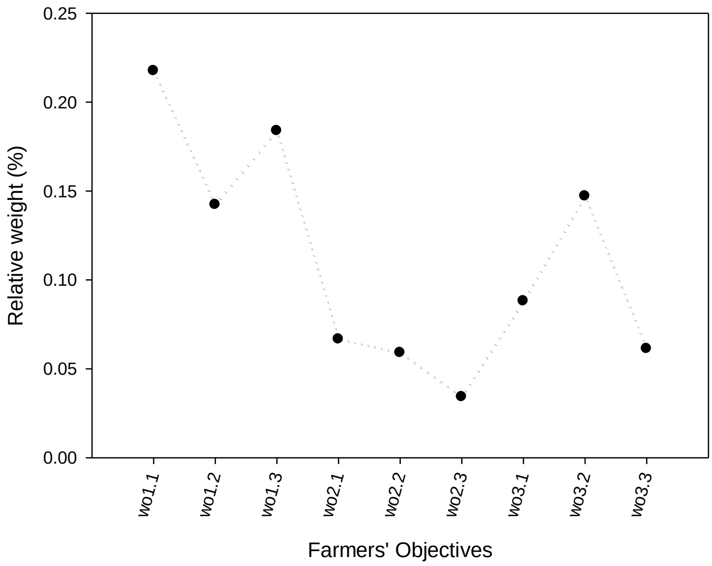

Figure 11. Prioritization and ranking of the relative weights of the farmers' objectives

2.4.4 Heterogeneity of Farmers' Objectives

As stated in the former point, we have shown that there is an ample heterogeneity among the different types of farmers in relation with the objectives that guide their decisions concerning production. In this section we would like to study more in detail the factors that determine this heterogeneity. For that purpose, we have specified a model where the dependent variable is the farmers' objectives and where the explanatory one is the socioeconomic variables taking into account the dependent variable's nature. We have relied on the Tobil model (Tobin, 1958) which allows explaining data that in some occasions entail problems with censure that is when not all of the individuals of the sample behave in the same manner. The results show different variables that are statistically meaningful with estimated values of probability lower than 0.05 and a 90% of confidence. The Chi square of the odds ratio indicates that estimated variables as a whole are different from zero (Scott, 1997).

When we analyze the relation between the socioeconomic variables and the farmers' objectives in three segments we observe that the goodness-of-fit is satisfactory according to the likelihood function and the significance of the variables confirm that the groups of farmers differ in their objectives (Table 7).

Generally, just as Table 7 shows, the coefficient of the members-of-household variable (V1) is meaningful for the three objectives but it is negative for the sociocultural and environmental objectives. This confirms the fact that the higher the number of family members the greater the income necessary to satisfy the needs of the household (Blanco and Bardomás, 2015).

Another important variable is having basic education (V3) and/or that a member of the family has done university studies (V5) since it positively affects both economic and sociocultural objectives.

The number of generations dedicated to farming (V6) is a variable that affects economic objectives. This is due to the continuity of family legacy and traditions, coupled with the fact that the investments acquired by the head of the family (machinery and lands) are planned for them to be used in the long term (Berrone et al. 2010).

When the employees of the farm are the main source of information (V7) the sociocultural and environmental objectives are positively affected whereas the economic objective is negatively affected. The maize employees play a central role in maintaining the biodiversity to build a natural, cultural and social heritage for the community (Hellin and Bellon, 2007).

In this way, the lack of organization of the maize productive system (V8) and the potential for acceptance of improved maize seeds (V14) affect the sociocultural and environmental objectives. This coincides with Lutz and Herrera (2007) when they mention that adequate levels of organization and training will allow the farmers to take advantage and to stablish scale economies, to stablish mechanisms to protect the environment, to develop their infrastructure and to create their own instruments of financial support.

In the same way, the economic and sociocultural objectives are positively affected by the number of hectares (V11) and the yield (V12). Nevertheless, total sales (V13) affect the economic objectives in a negative way because the income received for the maize crop does not affect the recovery of production costs (Ayala et al. 2013).

Sociocultural and environmental objectives are positively related to the low risk aversion (V15). This means that it is normal that the farmers face any innovation with uncertainty and preconceived ideas about their effects (Allub, 2001).

Table 7. TOBIT model left-censored for the estimation of the corn farmers' objectives

Variable	Eco.	Soc.	Amb.	Eco.			Soc.			Amb.		
	TOTAL			Trans.	Cons.	Inno.	Trans.	Cons.	Inno.	Trans.	Cons.	Inno.
							Variables sociodemográficas					
V1	0,017***	-0,006**	-0,010**	-0,017**	-0,036	0,039**	0,006**	-0,016*	-0,014**	0,011**	0,054***	-0,023**
V2	-0,018	0,023**	-0,005*	0,003*	-0,020	-0,070	-0,020*	0,028*	0,214*	0,016*	-0,005	-0,129
V3	0,074**	0,016**	-0,087	0,088*	0,029	0,157**	-0,058	0,119***	0,052**	-0,044	-0,135	-0,195
V4	0,040*	-0,003*	-0,035	0,002	0,331***	0,218**	0,043*	-0,007	-0,036	-0,045	-0,321	-0,178
V5	0,071***	0,025**	-0,089	0,051**	0,264**	0,093**	0,030**	-0,069	0,025*	-0,070	-0,182	-0,110
V6	0,048**	-0,008*	-0,037*	0,072*	0,024*	0,049**	0,014*	0,002*	-0,012**	-0,085	-0,028*	-0,032*
V7	-0,009**	0,006***	0,007***	0,004**	-0,001**	-0,012**	0,002***	-0,004**	-0,001**	-0,003**	0,008**	0,011***
V8	-0,024*	0,077**	-0,051*	-0,197*	0,098	0,005	0,057**	0,034*	0,119**	-0,038*	-0,146	-0,119
						Variables sobre la explotación						
V9	-0,345	0,099	0,229**	-0,182	0,374	-0,464	0,046	0,097	0,052	0,124	-0,474	0,363***
V10	0,039*	0,014**	-0,052	-0,020	0,295**	0,063	0,013*	-0,084	0,021*	0,006*	-0,225	-0,077
V11	0,048***	0,018***	-0,064	0,083**	-0,038	0,105**	0,005**	0,028**	0,018**	-0,081	-0,004*	-0,120
V12	0,014**	0,005**	-0,021*	0,001*	-0,065	0,174*	0,007**	0,014**	-0,044	-0,012*	0,045**	-0,132
V13	-0,001***	0,002	0,001	-0,001***	0,007	-0,002***	-0,001***	-0,001***	-0,007***	0,001	0,004	0,002
						Actitudes y riesgo						
V14	0,036*	-0,042*	0,001**	0,177*	-0,151	-0,088	-0,087	0,079**	-0,053	-0,094	0,074**	0,127**
V15	-0,078	0,019**	0,059**	-0,186	-0,094	-0,202	0,094**	-0,002*	0,039**	0,102**	0,076**	0,152**
_cons	0,785	-0,133	0,345***	0,752	-0,302	0,062	-0,090	0,34	-0,008	0,345	1,002	0,969
LR Chi2	44,28	54,42	53,54	42,29	27,42	45,34	41,63	23,42	38,71	29,14	49,79	46,63
Prob > chi2	0,0101	0,0004	0,0008	0,0120	0,0522	0,0004	0,0100	0,1031	0,0031	0,2150	0,000	0,0002

The name of the variables is given in Table 2 .Level of significance: ***p < 0,01; **p < 0,05; *p < 0,10.

2.5 Conclusions

There is a lack of knowledge in most farmers concerning the improved seeds which is mainly due to lack of information and dissemination about their advantages. One important disadvantage consists mainly in the dependence to buy the seeds since, in spite of the fact that farmers can check the seeds before they purchase them, the farmers greatly depend on the quality of information offered by the supplier in respect of their characteristics and adaptability.

The corn farmers of the state of Chiapas are segmented according to their attitudes and perception towards improved seeds. Therefore, the commercial and marketing approaches must be different and adapted to each farmers' typology. The transitional farmers have a greater interest in economic objectives. These farmers are in the stage of assessment of the innovation. Therefore, if we are aiming at their conversion into improved seeds it is necessary to develop an efficient and timely extension service

which underlines the improvement of the grain's yield and quality, and therefore the improvement of its income.
The innovators are more interested in the environmental objectives. These farmers are a potential group to adopt, and they can help to disseminate improved seeds by sharing their experience with neighboring farmers or by using their plots of land to demonstrate their benefits. It is important to continue to update and to rely on technological innovations. The use of a technological innovations package as a whole, and not only at technical innovation level such as the use of improved seed, is indispensable for the crop's improvement.

The conservatives are more interested in the sociocultural objectives. These farmers are not being assisted either by the extension service or by the seed companies. Nevertheless, the farmers who decide to keep on growing Creole varieties can focus on a very well defined market niche. In the same way, it will be necessary to improve the productivity of the native races of maize through sustainable practices with the purpose of maintaining the milpa system. The compound seeding can be more productive because it measures not only the crop yield but the total production of farmed species.

When analyzing the relationship between the characteristics of farmers, farm's structure, agricultural management, external factors, attitudes and opinions, we observed that they play a prominent role in determining the economic, sociocultural and environmental objectives of the maize farmers within the area of study. Thus, it is primordial to take into account the farmers' typology, preferences and objectives when defining the strategy to increase the adoption rate of and the improved corn seeds. Therefore, agricultural policy should be locally adapted and consistent with the farms' needs in each region needs. Efficient and differentiated agricultural and rural policies may play an important role in wealth distribution which can increase the level of economic development and social equality.

Likewise, we can't forget that Mexico is the center of origin of maize and a very important world center of biodiversity. The challenge consists in increasing the production of maize in a sustainable way and without degrading the natural resource base. The germplasm banks represent an essential instrument to safeguard diversity and for the sustainability of agricultural research and production. The impact of this increase of sown area with improved varieties is still the object of a debate. Based on that, it is necessary to analyze the percentage of land that must be destined to Creole varieties so that they may still contribute to the biodiversity preservation.

2.6 References

Aczél, J., Alsina, C. (1986). Onsynthesis of judgements. Socio-Economic *Planning Science*, 20(6): 333-339.

Aczél, J., Saaty, T. (1983). Procedures for synthesizing ratio judgments. *Journal of Mathematical Psychology*, 27(1): 93-102.

Allub, L. (2001). Aversión al riesgo y adopción de innovaciones tecnológicas en pequeños productores rurales de zonas áridas: un enfoque causal. *Estudios Sociológicos,* 9 (2): 467–493.

Asrat, S., Yesuf, M., Carlsson, F., Wale, E. (2010). Farmers' preferences for crop variety traits: Lessons for on-farm conservation and technology adoption. *Ecological Economics,* 69(12): 2394–2401.

Ayala, A., Schwentesius, R., O-Olán, M., Preciado, P., Almaguer, G., Rivas, P. (2013). Análisis de rentabilidad de la producción de maíz en la región de Tulancingo, Hidalgo, México. *Agricultura Sociedad y Desarrollo,* 10(4): 381–395.

Bellon, M., Risopoulos, J. (2001). Small-Scale Farmers Expand the Benefits of Improved Maize Germplasm: A Case Study from Chiapas, Mexico. *World Development,* 29(5): 799–811.

Bellon, M., Taylor, J. (1993). "Folk" Soil Taxonomy and the Partial Adoption of New Seed Varieties. *Economic Development and Cultural Change*, 41: 763–786.

Berrone, P., Cruz, C., Gomez, L., Larraza, M. (2010). Socioemotional Wealth and Corporate Responses to Institutional Pressures: Do Family-Controlled Firms Pollute Less? *Administrative Science Quarterly*, 55: 82–113.

Birol, E., Smale, M., Yorobe, J. (2012). Bi-modal preferences for Bt maize in the Philippines: A latent class model. *AgBioForum*, 15(12): 175–190.

Blanco, M., Bardomás, S. (2015). Agrario y no agrario: ingresos de hogares rurales argentinos. *Revista Mexicana de Sociología*, 77(1): 95–127.

Cabrera, E., Rodríguez, M., Arriaza, M. (2014). La influencia del manejo del suelo en la función ambiental del olivar según la opinión de expertos. *Revista Española de Estudios Agro sociales y Pesqueros*, 238: 81–104.

Cavallo, E., Ferrari, E., Bollani, L., Coccia, M. (2014). Attitudes and behaviour of adopters of technological innovations in agricultural tractors: A case study in Italian agricultural system. *Agricultural Systems*, 130: 44–54.

Ceballos, A., López, J. (2003). Delineation of suitable areas for crops using a Multi-Criteria Evaluation approach and land use/cover mapping: a case study in Central Mexico. *Agricultural Systems,* 77: 117–136.

CEIEG. (2015). Secretaría de planeación, gestión pública y programa de gobierno. Acceso Marzo 2016 en http://www.ceieg.chiapas.gob.mx/perfiles/Inicio

Chin, K., Xu, D., Yang, J., Ping-Kit, J. (2008). Group-based ER–AHP system for product project screening. *Expert Systems with Applications*, 35: 1909–1929.

Chirwa, E. (2005). Adoption of fertiliser and hybrid seeds by smallholder maize farmers in Southern Malawi. *Development Southern Africa*, 22(1): 1–12.

CIMMYT. (1993). La Adopción de Tecnologías Agrícolas: Guía para el Diseño de Encuestas. Programa de Economía. México, DF. 88 p.

Córdova, H., Castellanos, S., Bolaños, J. (2002). Veinticinco años de mejoramiento en los sistemas de maíz en Centroamérica: logros y estrategias hacia el año 2000. *Agronomía Mesoamericana*, 13: 73–84.

Coutiño, B., Betanzos, E., Ramírez, A., Espinoza, N. (2004). V-229 y V-231A, nuevas variedades mejoradas de maíz de la raza Comiteco. *Revista Fitotecnia Mexicana*, 2783: 295–296.

De Cock, L. (2005). Determinants of organic farming conversion. Paper presented at the XI International Congress of The European Association of Agricultural Economists, Copenhagen, Denmark. 13p.

Feder, G., Just, R., Zilberman, D. (1985). Adoption of Agricultural Innovations in Developing Countries: A Survey. *Economic Development and Cultural Change*, 33(2): 255–298

Forman, E., Peniwati, K. (1998). Aggregating individual judgments and priorities with the analytic hierarchy process. European Journal of Operational Research, 108(1): 165–169.

Fundación Produce Chiapas A.C. (2011). Agenda Estatal de Innovación. Programa de Desarrollo de Capacidades, Innovación Tecnológica y Extensionismo Rural Componente: Innovación y Transferencia de Tecnología. Chiapas, México. 124p.

Galindo, G. (2007). El servicio de asistencia técnica a los productores de chile seco en Zacatecas. *Convergencia*, 14(43): 137–165.

García, A., Guzmán, S. (2015). Factores que afectan la demanda de semilla mejorada de maíz en México. *Revista fitotecnia mexicana*, 38(3): 319–327.

García, J., Noriega, S., Díaz, J., Riva, J. (2005). Aplicación del proceso de jerarquía analítica en la selección de tecnología agrícola. *Agronomía Costarricense*, 30(1): 107–114.

Gerber, J., Carsjens, J., Pak-uthai, T., Robinson, T. (2008). Decision support for spatially targeted livestock policies: Diverse examples from Uganda and Thailand. *Agricultural Systems*, 96: 37–51.

Ghadim, A., Pannell, D., Burton, M. (2005). Risk, uncertainty, and learning in adoption of a crop innovation. *Agricultural Economics*, 33(1): 1–9.

Gómez-Limón, J., Atance, I. (2004). Identification of public objectives related to agricultural sector support. *Journal of Policy Modeling*, 26(8): 1045–1071.

Guillem, E., Murray, D., Robinson, T., Barnes, A., Rounsevell, M. (2015). Modelling farmer decision-making to anticipate tradeoffs between provisioning ecosystem services and biodiversity. *Agricultural Systems*, 137: 12–23.

Hair, J., Anderson, E., Tatham, R., Black, W. (1998). Multivarte Data Analysis. Prentice-Hall International, Inc. New Jersey, USA. 730 p.

Hellin, J., Bellon, M. (2007). Manejo de semillas y diversidad del maíz — AgriCultures Network. *LEISA Revista de Agroecología*, 23(2): 9–11.

Hellin, J., Keleman, A. (2013). Las variedades criollas del maíz, los mercados especializados y las estrategias de vida de los productores. *LEISA Revista de Agroecología*, 29 (2), 9–14.

Hernández, A., Cardells, F. (1999). Aplicación del método de las jerarquías analíticas a la valoración del uso recreativo de los espacios naturales de Canarias. Revista de la Consejería de Política Territorial y Medio Ambiente, Gobierno de Canarias, 13.

Herrera, E., Macías, A., Díaz, R., Valadez, M., Delgado, A. (2002). Uso de semilla criolla y caracteres de mazorca para la selección de semilla de maíz en México. *Rev. Fitotecnia Mexicana,* 25(1): 17–23.

Howley, P., Buckley, C., Donoghue, C., Ryan, M. (2015). Explaining the economic "irrationality" of farmers' land use behaviour: The role of productivist attitudes and non-pecuniary benefits. *Ecological Economics,* 109: 186–193.

Immink, M., Alarcon, J. (1993). Household Income, Food Availability, and Commercial Crop Production by Smallholder Farmers in the Western Highlands of Guatemala. *Economic Development and Cultural Change,* 41: 319–342.

INEGI. (2015). Encuesta Nacional Agropecuaria ENA 2014. Resultados. Access july 2016, in http://www.inegi.org.mx/est/contenidos/proyectos/encuestas/agropecuarias/ena/ena2014/doc/pre sentacion/ena2014_pres.pdf

Kallas, Z., Gil, J. (2012). Combining contingent valuation with the analytical hierarchy process to decompose the value of rabbit meat. *Food Quality and Preference*, 24(2): 251–259.

Kallas, Z., Gómez-Limón, J. (2007). Agricultural Multifunctionality Valuation : A Case Study Using The Choice. *Estudios de economía aplicada,* 25: 107–144.

Kallas, Z., Serra, T., Gil, J. (2010). Farmers' objectives as determinants of organic farming adoption: the case of Catalonian vineyard production. *Agricultural Economics,* 41(5): 409–423.

Kamara, A., Kureh, I., Menkir, A., Kartung, P., Tarfa, B., Amaza, P. (2006). Participatory on-farm evaluation of the performance of drought-tolerant maize varieties in the Guinea savannas of Nigeria. *International journal of food, agriculture and environment,* 4: 192–196.

Karami, E. (2006). Appropriateness of farmers' adoption of irrigation methods: The application of the AHP model. *Agricultural Systems,* 87: 101–119.

Karanja, D., Renkow, M., Crawford, E. (2003). Welfare effects of maize technologies in marginal and high potential regions of Kenya. *Agricultural Economics*, 29: 331–341.

Knowler, D., Bradshaw, B. (2007). Farmers' adoption of conservation agriculture: A review and synthesis of recent research. *Food Policy,* 32: 25–48.

Langyintuo, S., Mwangi, W., Diallo, A., MacRobert, J., Dixon, J., Bänziger, M. (2010). Challenges of the maize seed industry in eastern and southern Africa: A compelling case for private–public intervention to promote growth. *Food Policy,* 35(4): 323–331.

Lee, D. (2005). Agricultural Sustainability and Technology Adoption: Issues and Policies for Developing Countries. *American Journal of Agricultural Economics,* 87(5): 1325–1334.

Li, J., Lammerts, E., Jiggins, J., Leeuwis, C. (2012). Farmers' adoption of maize (Zea mays L.) hybrids and the persistence of landraces in Southwest China: implications for policy and breeding. *Genetic Resources and Crop Evolution,* 59: 1147–1160.

Lutz, B., Herrera, F. (2007). Organización de productores de maíz en el Estado de México: papel de las instituciones e importancia de las coyunturas políticas. *Ciencia Ergo Sum.,* 14(1):15-26.

Magorokosho, C. (2006). Genetic diversity and performance of maize varieties from Zimbabwe, Zambia and Malawi. Doctoral dissertation, Texas A&M University. Texas A&M University. Available electronically from http : / /hdl .handle .net /1969 .1 /4669.

Moreno, J. (2002). El Proceso Análitico Jerárquico (AHP). Fundamentos, metodologías y aplicaciones. *Recta monográfico,* 1: 21–53.

Nandi, R., Gowdru, N., Bokelmann, W., Dias, G. (2015). Smallholder organic farmer's attitudes, objectives and barriers towards production of organic fruits and vegetables in India: A multivariate analysis. *Emirates Journal of Food & Agriculture,* 27(5): 396-406.

Parra, C., Calatrava, J., De-Haro, T. (2008). A systemic comparative assessment of the multifunctional performance of alternative olive systems in Spain within an AHP-extended framework. *Ecological Economics,* 64: 820–834.

Peng, J., Liu, Z., Liu, Y., Hu, X., Wang, A. (2015). Multifunctionality assessment of urban agriculture in Beijing City, China. *Science of The Total Environment,* 14 (537): 343–351.

Requena, C., López, J. (2005). Factors related to the adoption of organic farming in Spanish olive orchards. *Spanish Journal of Agricultural Research,* 3(1): 5–16.

Rivera, A., Romero, H. (2003). Evaluación del nivel de transferencia y adopción de tecnología en el cultivo de caña de azúcar en Córdoba, Veracruz, México. *Avances en la Investigación Agropecuaria,* 21(2): 20–40.

Rogers, E. (1986). Diffusion of Innovations. Fourth ed. New York: The Free Press. U.S.A. 251 p.

Rojas, R. (2005). Guía para Realizar Investigaciones Sociales. 40a ed. Plaza y Valdez S.A. México, D.F. 237 p.

Romero, C., Rehman, T. (2003). Multiple criteria analysis for agricultural decisions. Second edition. Elsevier Science B. V. Hungary. No. 11.

Saaty, T., Vargas, L. (1984). Comparison of eigenvalue, logarithmic least squares and least squares methods in estimating ratios. *Mathematical Modelling,* 5(1): 309–324.

Saaty, T. (1980). The analytic hierarchy process. New York: McGraw-hill.

SAGARPA. (2015). Secretaría de Agricultura, Ganadería, Desarrollo Rural, Pesca y Alimentación. Acceso Febrero 2016 en http://www.gob.mx/sagarpa

Salazar, J., Rivera, H., Arévalo, S., Guevara, A., Mald, G., Raascón, Q. (2015). Calidad del nixtamal y su relación con el ambiente de cultivo del maíz. *Fitotec. Mex.,* 38(1): 67–73.

Scott, J. (1997). Regression models for categorical and limited dependent variables. California. United States: Sage Publications. 282 p.

SIAP. (2016). Avances de Siembras y Cosechas por Estado y Año Agrícola. Secretaría de Agricultura, Ganadería, Desarrollo Rural, Pesca y Alimentación. Acceso Marzo 2016 en http://www.gob.mx/siap

Sibiya, J., Tongoona, P., Derera, J., Makanda, I. (2013). Farmers' desired traits and selection criteria for maize varieties and their implications for maize breeding: A case study from Kwazulu-Natal Province, South Africa. *Journal of Agriculture and Rural Development in the Tropics and Subtropics*, 114(1): 39–49.

Smale, M., Richard, J., Howard, L. (1994). Land Allocation in HYV Adoption Models: An Investigation of Alternative Explanations. Agricultural. *American Journal of Economics*, 76(3): 535–546.

Tobin, J. (1958). Estimation of relationships for limited dependent variables. *Econométrica,* 26:24-36.

Turrent, A., Wise, A., Garvey, E. (2012). Factibilidad de alcanzar el potencial productivo de maíz de México. *Mexican Rural Development Research Reports,* 24: 1-36.

Valdivia, R., Caro, F., Ortiz, M., Betancourt, A., Ortega, A., Vidal, V., Espinosa, A. (2007). Desarrollo participativo de híbridos sintéticos de maíz y producción de semilla por agricultores. *Agricultura técnica en México,* 33(2): 135–143.

Valdivia, R., Espinosa, A., Tadeo, M., Caro, F., Aguilar, J., Vidal, V., … López, G. (2015). "Cora 2012": híbrido intervarietal de maíz para Nayarit y regiones similares. Revista mexicana de ciencias agrícolas, 6(2): 417–420.

Veisi, H., Liaghati, H., Alipour, A. (2016). Developing an ethics-based approach to indicators of sustainable agriculture using analytic hierarchy process (AHP). *Ecological Indicators,* 60: 644–654.

Xu, M., Zhang, C. (2009). Bankruptcy prediction: the case of Japanese listed companies. *Review of Accounting Studies,* 14(4): 534–558.

Young, Y., Rigby, D., Burton, M. (2001). The development of and prospects for organic farming in the UK. *Food Policy,* 26:599-613.

SECONDLY PAPER: FARMER PREFERENCE FOR IMPROVED CORN SEEDS IN CHIAPAS, MEXICO: A CHOICE EXPERIMENT APPROACH

UNDER REVIEW: SPANISH JOURNAL OF AGRICULTURAL RESEARCH

CHAPTER 3

FARMER PREFERENCE FOR IMPROVED CORN SEEDS IN CHIAPAS, MEXICO: A CHOICE EXPERIMENT APPROACH

In order to increase the adoption of improved seeds, appropriate technologies must be developed that considers the preferences of farmers. Our research identifies the key attributes as the main determining factors when selecting the improved varieties of maize seeds and landraces, identifying the farmers' willingness to pay (WTP) for each attribute, and analyzing their observed heterogeneity, while taking into account several socio-economic variables. Data were collected in the state of Chiapas, Mexico with a semi-structured questionnaire of a sample of 200 farmers. A discrete-choice experiment was applied using a proportional choice variable, where farmers were asked to state the percentage of preference for different alternative varieties in a choice set. The Generalized Multinomial Logit (GMNL) model in WTP-space model approach was used. The results suggest that the improved seed varieties were more preferred than the Creole alternative varieties, showing a heterogeneous WTP to ensure higher yields, resistance to diseases, and larger ear size. For the preference heterogeneity analysis, a latent class model was applied. Three types of farmers were identified: innovators (60.5%), transition farmers (29.4%), and conservative farmers (10%). Thus, understanding farmer preferences can be useful for designing agricultural policies and creating pricing and marketing strategies as a key factor to facilitate the dissemination of good quality seed.

3.1 Introduction

In Mexico in the 1970s, there was a dramatic increase in food production; however, since then, the country has gradually lost its self-sufficiency in food production, which has led to an increase in imports of food and supplies for agriculture and agro-industry (FAOSTAT, 2016).

In 2015 corn production in Mexico estimated in 24.9 million tonnes with yields of 2.95 tonnes per hectare and an increase in imports of 77% (SIAP, 2016). The lack of corn productivity in Mexico is a national security issue because it is the main product used in the feeding of the population, especially in rural areas that are in extreme poverty and experience high marginalization. It is estimated that the annual consumption of corn is 123 kg per capita, well above the world-wide average of 16.8 kg per capita (FAOSTAT, 2016). Projections from the Food and Agriculture Organization of the United Nations estimate that by 2050, corn production will not satisfy the global demand, as a result of climate change, the shortage of production inputs, and the emergence of new pests and diseases. Consequently, the price of basic grains will increase on the international market and will become progressively more expensive, making it difficult for Mexico to import grains. Therefore, improving corn productivity is essential to meet the future demand of the population.

It has been estimated that the potential for maize production in Mexico is 52 million tonnes, of which 28 million would be feasible to achieve in the short term. This short-term increase could be reached without increasing the amount of agricultural land used and without using transgenic maize. Additionally, by applying improved technology to maize production, including the use of highly productive seed varieties and adapted farming practices (Turrent et al. 2012). Such improvement in productivity is hard to achieve on large-scale farms with already adopted technology and highly productive varieties. In this context, the main challenge hinges on small-scale farmers in improving or maintaining their productivity by more efficient use of the available resources and capital through the adoption of innovations at the farm level. Such agricultural technologies include the use of improved varieties, new agricultural practices, and sustainable use of chemical fertilizers. According to Copeland and McDonald (2001), the seeds of improved varieties are the most effective means to increase yields and improve the quality of the crops.

For several years, the Federal Government of Mexico has invested in breeding through a variety of public and private institutions in order to increase productivity; however, there is a lack of coordination among the formal institutions engaged in research and development activities, as well as weak linkages between these institutions, farmers, and private sector firms (Spielman et al. 2011). Accordingly, this situation has led to the development of improved varieties without taking into account the preferences of farmers, especially in marginal areas (Hellin et al. 2006), which in turn causes of a low rate of adoption (Luna et al. 2011). To illustrate this issue, one example is the state of Chiapas, which is mainly characterized by an agricultural system dominated by small farmers and low yields of 1.6 tha^{-1} (SIAP, 2016). Further, Chiapas has the largest demand for corn seed and the highest potential for increased production; although, it is still one of the states with the lowest implementation rates of improved seeds (30%), due to the low-perceived advantage of this technology (INEGI, 2015).

In this context, Bellon (1991) shows that farmers are not a uniform group and their preferences and priorities are highly heterogeneous. With this in mind, many determining factors affect farmers' choice of seeds. Their selection depends on the final product attributes, socioeconomic variables, opinions and attitudes, risk perception, the sociocultural environment, and the amount of information they have access to (Hellyer et al. 2012). Morris and Bellon (2004) noted that plant breeders often have weak links to the end user. This is partly due to their professional training: plant breeders receive rigorous instruction in the theory and practice of crop improvement and have little exposure to survey methods needed to elicit structured feedback from farmers. As a result, what the conventional plant breeder considers important in a variety might not correspond with the preferences of the majority of farmers in an agricultural system or region. Consequently, the breeding program may result in selecting a non-optimal combination of characteristics (Morris and Bellon, 2004). Accordingly, the best strategy to increase the improved seeds is to develop appropriate technologies that take into consideration the heterogeneity of farmers, their production constraints, and what really influences their final decisions in farming activities (Sibiya et al. 2013).

In recent years, participatory plant-breeding programs that seek to recover the participation of the farmer in breeding programs have become relevant. Notably, the inclusion of farmers' opinions and preferences in the design and development of technological innovations is scarce in Mexico (Castillo and Chávez, 2013; Birol et al.

2009; Birol et al. 2006b; 2013; Herrera et al. 2002). Specifically, in the State of Chiapas, some research regarding preferences toward maize attributes have been carried out through a participatory method and following non-parametric techniques (Hellin et al. 2006; Martínez et al. 2006; Bellon and Risopoulos, 2001).

Considering these things, the objectives of our research are twofold: we seek (1) to identify key attributes and determining factors of choice of maize seeds by local farmers, and (2) to estimate farmer WTP for each descriptor and their heterogeneity on the basis of socio-economic characteristics. Furthermore, among approaches that analyze preferences, the Discrete Choice Experiment (DCE) is one of the most applied approaches due to its validated economic theory. In this study, the DCE was used to measure the WTP a premium for a set of different attributes that characterize the maize seeds by estimating a GMNL in WTP-space model. Furthermore, preference heterogeneity was assessed with the Latent Class (LC) Modeling approach to better understand farmers' choices in selecting seeds. Our research contributes to the existing literature on analyzing farmer preference of seed selection in Mexico by providing specific information at marginal areas in order to promote a "social breeding" program for the improved seed sector that considers the needs of small farmers by increasing their likelihood to adopt. Secondly, this paper contributes to DCE studies by introducing the choice variable as a proportional specification in the modeling approach by estimating the percentage of the different corn seed preferred in a choice set.

3.2 Methods: the choice experiment

The current literature provides several tools designed to analyze product preference such as participative research (Ferro et al. 2013; Bellon and Risopoulos 2001), conjoint analysis (Hirpa et al. 2012; Makokha et al. 2007), and the use of descriptive analyses (Sibiya et al. 2013). In the early 80's, the DCE was introduced as a technique to model consumer choices (Louviere, 2001). Thereafter, DCE's became one of the most used tools in research for analyzing individual behavior and choice. DCE's were first used in communication and transport (Louviere, 1981); however, their use gradually spread to other areas like market research (Bastell & Louviere, 1991), environmental valuation (Hanley et al. 1998), identifying attributes of products on behalf of consumers (Lusk et al. 2003), and agricultural multifunctionality (Kallas and Gómez-Limón, 2007).

Windle and Rolfe (2005) used this methodology to analyze alternatives for the diversification of Australian agriculture. This method has also been used in organic agriculture (Meas et al. 2015), food traceability (Wu et al. 2015), and to maintain or enhance programs for plant and animal improvement (Asrat et al. 2010; Roessler et al. 2008). However, empirical applications of DCE on farming innovations are few. Furthermore, Birol and Villalba (2006) noted that DCE can be successfully used in developing countries such as Mexico, as long as it is used with a careful selection of the election sets and an effective compilation of data in the field. In Mexico, choice experiments have been used in natural reserves (Walter 2010), in preferences of trait selection of pig breeds (Scarpa et al. 2003), and in the assessment of transgenic corn crops in the states of Jalisco, Michoacán, and Oaxaca (Birol and Villalba, 2006).

DCE aims to identify the individual's indirect utility function, associated with the attributes of products, by examining the trade-offs consumers consider when making choices at a retail outlet. DEC relies on the theory of random utility (RUM) that poses that the utility of an individual, n, choosing an alternative, j $(\cup_j^n, j = 1, \dots, J)$ is the sum of the components: V_j^n, which is a function of the characteristics of the alternative (X_j^n), individual characteristics (S_n); as well as another random component, ε_j^n. To illustrate further, the individual, n, will choose the alternative, j, if it provides a utility that is superior to any other alternative, i, available in the choice set.

Among the various modeling approaches that analyze choice data, Fiebig et al. (2010) proposed the Generalized Multinomial Logit (GMNL) model, which is focused on estimating the scale parameter. This estimate represents the variation of degree of randomization in the process of making decisions, and the degree of certainty of individuals when making a choice. According to the aforementioned model, the utility of an individual, i, for selecting alternative, j, in a choice set, t, is given in the following formula:

$$U_{njt} = [\sigma_n \beta + \gamma n_n + (1 - \gamma)\sigma_n n_n] + \varepsilon_{njt} \quad (1)$$

Where γ is a mixing parameter between 0 and 1, whose value represents the level of independence or interaction between the scale term σ_n and the heterogeneity around the attributes' estimates (n_n). Further details about the GMNL specification and estimation can be found in Fiebig et al. (2010). Following the GMNL the WTP can be estimated by calculating the ratio of the attributes' coefficients to the price fixed estimate; however, this ratio can be directly estimated using the WTP-space estimating approach (Train and Weeks, 2005). In this case, the GMNL can be reparametrized (Greene & Hensher, 2010) by separating the variable price, ρ, and its coefficient, $(\beta\rho, n)$, in (1):

$$U_{nj} = \sigma_n\left(-\beta_{\rho,n}\rho + \beta_n X_{nj}\right) + \varepsilon_{nj} = \sigma_n\beta_{\rho,n}\left(-\rho + \left(\beta_n\beta_{p,n}\right)X_{nj}\right) + \varepsilon_{nj} \qquad (2)$$

By standardizing the price coefficient, $(\beta\rho, n)$, of ρ to 1, the WTP can be directly estimated. In this case, the mixing parameter (γ) is fixed.

Finally, in order to analyze preference heterogeneity, different techniques can be used. Within the choice experiment approach, the socioeconomic variables are typically interacted with the attributes. The LC model is one of the most-used approach in analyzing observed heterogeneity. Besides the relevance of the socioeconomic variables in describing preferences, this model also provides a way to obtain more information regarding the different segments of the market. To illustrate, the model begins by contrasting the "segmentability" of the population studied. According to this model, The LC determines the probability of an individual to belong to a certain class and the class probabilities of choosing one alternative conditional on the preferences within each class. Further details regarding this model can be consulted in Greene and Hensher (2003). In this study, we used the LC to analyze farmers' preferences heterogeneity. The "best" number of classes to be extracted was based on the comparison of the Bayesian Information Indicator (BIC), McFadden pseudo R^2 and plausibility of the results.

3.3 Empirical application

3.3.1 Data

Data was collected from an in-person survey with a sample of 200 farmers that was carried out in January and March of 2015; the sample was stratified by seed variety (creole and improved). Also, the interviews were made in a zone of potential corn production in the state of Chiapas: the towns of Villaflores, Chiapas de Corzo, Villacorzo, and La Concordia. In order to determine the sample size, information were used regarding the farmers who were registered in the Programa de Apoyos Directos al Campo (PROCAMPO), a program which is intended to promote and finance agriculture in the counties mentioned above. Notably, farmers enrolled in this program represent 98% of total corn farmers SIAP (2015). Following Kallas et al. (2010), the questionnaire was organized in two sections: the first included open-ended questions about the characteristics of the farmers (gender, education, age, experience), farm structure (location, farm size, soil type), farm management (input use and crop diversification), exogenous factors (output and input prices, market size, subsidies, information access, transition costs); the second part included the different choice sets to carry out the choice experiment. Analyses of the econometric models were performed with NLOGIT 5.0 software.

3.3.2 Empirical application of the choice experiment

The application of the DCE in our case study can be summarized into the following steps: First the characterization of the decision problem was predefined in terms of changes to the existing state, status quo, and base reference point. In our research, the goal is to place values on the possible changes in the preferences of attributes when selecting the maize seeds and WTP for each seed type. The status quo in our case is therefore defined by the available supply of improved and creole seeds. Next, for the definition of attributes and their corresponding levels, we followed different studies and sources of information. To explain, the first step was to analyze current farmer preferences when selecting seed for crops. Results showed that the attributes that the farmer takes into account when selecting a new variety are the corn ear shape (Ferro et al. 2008), number of grains per row (Ferro et al. 2013; Ferro et al. 2008), corn ear filling arrangement (Ferro et al. 2013), grain color (Benz et al. 2007; Soleri and Cleveland, 2001), ear size (Ferro et al. 2013; Sibiya et al. 2013), ear height (Ferro et al. 2008), ear weight (Sibiya et al. 2013; Ferro et al. 2008), resistance to disease (Ferro et al. 2008), ear diameter (Ferro et al. 2008), ear tightness (Ferro et al. 2008), stem thickness (Ferro et al. 2008), number of rows per cob (Sibiya et al. 2013; Ferro et al. 2013), color of straw (Ferro et al. 2008), plant height (Ferro et al. 2013; Ferro et al. 2008), number of corn ears (Sibiya et al. 2013; Ferro et al. 2008), cob diameter (Herrera et al. 2002), early maturity (Sibiya et al. 2013), yield (Ferro et al. 2013; Sibiya et al. 2013; Birol et al. 2012), grain size (Sibiya et al. 2013; Bellon and Risopoulos, 2001), flavor (Sibiya et al. 2013), tolerance of drought (Sibiya et al. 2013; Bellon et al. 2006), tolerance of excessive rain (Sibiya et al. 2013; Bellon et al. 2006), resistance to putrefaction of the corn ear (Sibiya et al. 2013; Bellon et al. 2006), duration (cycle of growth) (Sibiya et al. 2013; Bellon et al. 2006), plague resistance (Sibiya et al. 2013; Bellon et al. 2006), resistance to storage plagues (Sibiya et al. 2013; Bellon et al. 2006), and yield for dough (Bellon et al. 2006). The product price is another important extrinsic attribute that affects the purchase decision (Lockshin et al. 2006). The second step was to conduct a discussion group formed by researchers from the Instituto Nacional de Investigaciones Forestales, Agrícolas y Pecuarias (National Institute of Forestry, Agriculture and Livestock) in order to reduce the primary information obtained. Also, this group allowed for the evaluation and verification of the suitability of the attributes. Subsequently, a pilot questionnaire to potential respondents was applied to test the validity of the attributes and levels. Regarding the cost attributes and levels, the price of corn seed was calculated from the average prices for a bag of 20 kg of seed, provided by the Instituto Nacional de Investigaciones Forestales, Agrícolas y Pecuarias (National Institute of Forestry, Agriculture and Livestock) and the Secretaría de Agricultura, Ganadería, Desarrollo Rural, Pesca y Alimentación (Office of the Secretariat of Agriculture, Livestock, Rural Development, Fisheries and Food). However, the price was correlated with the type of seed used. To solve this problem, we used a labeled choice design, where each alternative choice is defined by the type of seed used. In Table 8, the main attributes and their levels are given.

Table 8. Identification of attributes and their corresponding levels

Attributes	**Levels**	
	Creole	**Improved**
Price[1]	Low (\$100 - \$140) Medium (\$141 - \$180) High (\$181 - \$220)	Low (\$500 - \$900) Medium(\$901 -\$1300) High(\$1301 - \$1700)
Yield	Low (1.3 - 2. tha^{-1}) Medium (2.6 - 3.7 tha^{-1}) High (3.8 – 5.0 tha^{-1})	Low (6.0 - 9.0 tha^{-1}) Medium (9.1 – 12 tha^{-1}) High (12.1 – 15.0 tha^{-1})
Height	Low (1.30 - 1.80 m) Medium (1.81 - 2.40 m) High (2.41 - 3.00 m)	Low (1.30 - 1.80 m) Medium (1.81 - 2.40 m) High (2.41 - 3.00 m)
Ear length	Low (10.50-15 cm) Medium (15.1-19.5 cm) High (19.6-25 cm)	Low (10.50-15 cm) Medium (15.1-19.5 cm) High(19.6-25 cm)
Resistance to diseases	Low (up to 10%) Medium (up to 20%) High (up to 50%)	Low (up to 10%) Medium (up to20%) High (up to 50%)

[1]: Mexican pesos for a bag of 20 kilograms of seed

To design the experiment, forced labeled choice experiments were used that represent the different varieties of maize seed. An efficient blocked design with prior equal to zero was used (ChoiceMetrics, 2014) leading to 27 choice sets blocked into 3 groups.

Respondents were asked to set their preferences for the different alternative in a forced choice. No evidence was found in the piloting or the main survey of farmers that expressed any view that farmers would prefer to reject all the corn types in a choice set. An example a choice set can be seen in Figure 12.

If you can only choose one of the following items, which one would you choose?

Card A	**Creole**	**Improved**
Price	\$220	\$1,100
Yield	1.2 tha^{-1}	6 tha^{-1}
Height	2.2 m	2.2 m
Corn ear length	17.5 cm	17.5 cm
Resistance to disease	Up to 50%	Up to 20%
According to your total available land, please set the percentage of the different varieties of seed you would select for you maize cultivation this year.	______ **%**	______ **%**

Figure 12. Card sample and choice set

Finally, before beginning the survey, the normal procedure of the choice experiment was explained orally and in writing. Respondents were asked to set the percentage of the different varieties of seed they would select for their maize cultivation this year; thus, the dependent variable in this case study was a proportion of two mutually exclusive alternatives in each choice set. That is, the respondent gave preferences for the two alternatives, depending on the utility that it provided, and that decision produced a percentage. In contrast to the basic form of the choice experiment data set where respondents are asked to rank or select their preferred products, in our procedure, farmers were asked to set a percentage.

3.4 Results and discussion

3.4.1 Farmer preference on improved seeds

Results in Table 9 represent a summary of the major socio-demographic characteristics of the respondents. The proportion of each stratum is similar according to the total population of farmers in the geographical area where the study took place.

Table 9. Corn grower socio-demographic profile by seed type used

	Total
Gender (%)	
Female	23
Male	77
Age (years)	58.4
Level of education (%)	
No school education at all	58.1
Finished	25.3
Unfinished	16.6
Property right (%)	
Ejido land[1]	72
Small property	25
Hired	2
Communal	1
Year of start maize cultivation (year)	1981
Incomes from agriculture (%)	89
Incomes from maize (%)	90.5
Seed types (%)	
Creole	23
Improved	77

[1]: The Ejido land is the portion of land, forests and waters that the government gave a nucleus of rural population for their exploitation (INEGI 2015).

Results of the GMNL model in the WTP-space approach are shown in Table 10. The model showed a goodness-of-fit with an acceptable value of McFadden pseudo-R^2 that is equal to 0.169. The log likelihood ratio test was also highly significant at 99%. Results showed that the estimated coefficients of the majority of the levels of the attributes were statistically significant. This result confirms that most of the attributes and levels considered in the model were significant and essential in predicting farmers' preferences. The estimated parameters directly provide information about the WTP. Also, by analyzing the estimated WTP, farmers showed a positive WTP for the crop yield with a significant effect on farmers' choices. The same phenomenon occurred among the attributes regarding the resistance to disease and the ear length. Corn growers were willing to pay $15.80 for a 20-kilogram bag of improved corn seed in order to gain one more centimeter in corn ear length.

Furthermore, they are willing to pay $2.90 more in order to gain one percent of resistance to disease in the maize crop, and $39.89 more per bag to increase the crop yield by one ton. However, unexpectedly, farmers did not give importance to the attribute, "height of the corn," as it was not relevant in estimating farmers' choices; this attribute was not significant, despite the problems that this characteristic can cause for farmers. Nevertheless, our results confirm what Hellin and Bellon (2007) found in that farmers give more value to the corn stems used for making fences and leaves as forage. Therefore, considering the variety of corn, any corn type can be grown for forage, but the ones that give higher yields of bio-mass are the tall varieties. Improved varieties on the other hand, have a little bud sport and usually produce less forage per unit of area (Estrada et al. 2015); thus, as long as it is a high yield and wind-resistant stalk, farmers are willing to accept a tall plant. Additionally, the estimated the coefficient of the alternative specific constant (ASC) of the improved corn (that represent the unobserved factors by the researcher) was not significant. This result demonstrates that the attributes and levels that were not included in describing corn may not be relevant.

Table 10. Results of the GMNL in WTP- Space model for corn growers in Chiapas

Attributes	**β**	***p* value.**
	Random parameters in utility functions	
Price	1.0 .....(Fixed Parameter).....	
Corn ear length	0.15***	0.000
Corn stalk height	0.02	0.797
Resistance to disease	0.02***	0.000
Yield	0.39***	0.000
ASC of improved seed	0.12	0.540
	Variance parameter tau in GMNL scale parameter	
Variance parameter in scale parameter	3.76***	0.0000
	Mixing parameter in GMNL model	
Mixing parameter gamma	0.0 .....(Fixed Parameter).....	
	Coefficient on price in preference space form	
Beta0WTP	-2.29**	0.0238
S_b0_WTP	0.0 .....(Fixed Parameter).....	
Log likelihood function	-1036.13945	
Restricted log likelihood	1247.66493	
Pseudo-R^2	0.169	

Significance levels: *** p<0.01; **p<0.05

Our results are consistent with those found in the related literature in that they showed that the attributes taken into consideration as main drivers of utility when selecting improved seeds are: high yields, resistance to diseases, and lower costs (Asrat et al. 2010; Sibiya et al. 2013). In this context, Ajambo et al. (2010) mentioned that the corn farmers in Uganda preferred drought-resilient varieties, with a short growth cycle and higher resistance to pests and diseases; these farmers were willing to pay between Ush 200-5,000/kg for a variety with such characteristics (1 US $ = 2,200 Ug. USh). Comparatively, Kassie et al. (2014), points out that in Zimbabwe, farmers were willing to pay 1.75 times more in order to ensure tolerance to drought and be able to harvest one more ton of crop. They also found that producers were willing to pay 8.3 times the value to get a change in size from a small corn ear to a bigger one. Furthermore, regarding the attributes preference, the seed cost was also a highly important factor in describing preferences. Our results are similar to those found in other studies where the cost of the seed is a main determining factor that farmers take into consideration when choosing a variety (Kyeyune and Turner, 2016). Finally, regarding the scale factor, the estimate was high and significant, which confirmed a high level of unobserved heterogeneity and uncertainty in selecting the varieties. The results of the experiment in our study showed that the farmers demonstrated a high level of product uncertainty and randomness when they chose corn seed.

3.4.2 Farmers' observed heterogeneity toward corn seed preference

As previously mentioned, a LC model was used to analyze farmers' observed heterogeneity. This model allowed us it classify corn growers into three segments according to their preference for corn seeds. In order to identify the optimal number of segments, the Bayesian information criterion (BIC), the pseudo R^2, and probability of the result ($\rho 2$) of each segment (Hu et al. 2004) were used. Therefore, the LC model with three classes was selected as it revealed itself to be the best fit. From the sample of 200 farmers interviewed, we found that 60.5% were innovators, 29.4% were transition farmers, and 10% were conservative (Table 11).

Table 11. Results of the latent class model

	Coefficient	Prob.
Innovators (Latent class 1)	Utility parameters in latent class (1)	
Corn ear length	0.03	0.1110
Corn stalk height	0.41	0.1026
Resistance to diseases	0.01*	0.0632
Yield	0.14***	0.0029
ASC Improved seed	2.75***	0.0000
Price	-0.06**	0.0186
Transition farmers (Latent class 2)	Utility parameters in latent class (2)	
Corn ear length	0.01	0.1845
Corn stalk height	-0.02	0.8831
Resistance to diseases	-0.00	0.4598
Yield	0.08***	0.0073
ASC Improved seed	0.55*	0.0573
Price	-0.00	0.9077
Conservative farmers (Latent class 3)	Utility parameters in latent class (3)	
Corn ear length	0.09***	0.0082
Corn stalk height	0.13	0.5919
Resistance to disease	0.00	0.3907
Yield	0.08	0.1300
ASC Improved seed	-2.17***	0.0000
Price	-0.05*	0.0836
Estimated latent class probabilities		
Prb Innovators	0.60***	
Prb Transition	0.29***	
Prb Conservative	0.10***	
Log likelihood function	-657.18	
Restricted log likelihood	-1,247.66	
R^2	0.47	

Significance levels: *** p<0.01; **p<0.05, *p<0.1
ASC: alternative Specific constant

In Table 11, the first latent class was innovators gave high importance to seed yield, resistance to diseases, and price. Additionally, this group is the most sensitive to price. In the second latent class, transition farmers considered yield as the most important attribute, followed by a lesser preference for intensive seed type. In the third latent class, conservative farmers, on the other hand, considered the improved seeds as unimportant; instead, they preferred creole seeds and gave importance to a large corn ear and seed price. Furthermore, the negative sign of the coefficient of ASC implies that the survey respondents were very sensitive to changes in the quality of the election group and made decisions that are closer to both the theory of rational election and the behavior observed in reality (Dhar & Simonson, 2003). The global adjustment of the model, measured by R^2 of McFadden, was reasonable for the standards used in describing the probability models of discrete election (Ben-Akiva & Lerman, 1985).

In both classes 1 and 2, the alternative-specific constants (ASCs) were positive, a result contrasted in the negative ASCs of class 3. The difference in the ASC results between classes 1, 2, and 3 can be interpreted as the difference in the level of reserve utility associated with the non-observed attributes. Farmers belonging to class 3, exhibited a negative utility for the improved seed. Farmers belonging to either class 1 or class 2, had a strong or clear farming subculture and preferred to use improved seeds if they met the preferred attributes. Notably, the price had negative effects; that is, the lower the price, the higher utility for farmers, and consequently, the probability of choosing a product with a lower price increased, so a normal demand was consistent. It is essential to mention how important fertilizer complements are when using improved seeds, as they are necessary to obtain better yields. The amount of fertilizer needed is considerably higher when using improved seeds than when growing creole varieties (Bernard et al. 2010). In this respect, Gecho and Punjabi (2011) point out that the price of fertilizer lowers the probability of the adoption of technologies of improved corn. Furthermore, Salgado and Miranda (2010) point out that the increase in corn productivity in Mexico in the coming years will be subject to the price of fertilizers.

3.4.3 Profile of the corn farmer segments

Once the differences among the three segments had been described according to preferences for the different attributes, the next step was to create a profile for each latent class. Thus, each segment was described on the basis of the different variables available in the questionnaire and contrasted using the bivariate statistics inference (ANOVA, Tukey and Chi square). Knowing the type of farmers that belong to each segment can help in the establishment of well-defined agricultural policies and local intervention strategies. To do so, we first described each segment, using the socio-demographic characteristics. These characteristics included the farmer’s age, the number of generations in agriculture, the number of generations in corn farming, the year responsible for exploitation, and the year when the corn farming began. Besides these socio-demographic variables, we were also interested in data related to land management such as seed being used, corn sales, total surface, yield, total sales, distance from home to the exploitation field, and soil quality. In our study, soil quality was determined on a 0 to 10 scale, where 0 showed that the farmer considered the soil they had to be of bad quality, and 10 showed that the farmer considered the soil to have excellent quality. Attitudes, opinions and perceptions towards risk also play an important role in determining factors for implementation (Howley et al. 2015). Thus, in our profiling analysis, we also included the perception towards the improved seed and risk attitude. Risk attitudes and opinions toward improved seeds were obtained from conducting two principal component analysis (PCA) using different affirmation regarding the risk behavior following (Valdivia et al. 2015; Li et al. 2012; Birol et al. 2012; Asrat et al. 2010). Table 12 shows the profile for each of the segments, respectively.

Results showed that innovators were 52 years old on average. They started cultivating corn in 1980 and showed a positive acceptance of improved seeds. These farmers mainly cultivated improved seeds with higher yields per hectare and achieved greater sales. These farmers were shown to own more land, which is consistent with what Kalinda et al. (2014) found that the rate of improved corn seed use is directly related to the size of land. However, these farmers were shown to be risk acceptors, as they had more resources to mitigate the effects of such risks when adopting new technology. Transaction costs per surface unit were lower than they would be for farmers owning small areas, as Paredes and Martin (2007) mentioned in their study. Comparatively, transition farmers, showed an average age of 58 and were the fourth generation to grow corn. They gave less importance to soil quality, compared to other classes. They were, on average, risk takers and cultivated improved and creole seeds, depending on accessibility during the period of cultivation since improved seed has a high price attached to it. They took into account the information provided by their employees and tried to improve seeds on an experimental scale on their farms.

Finally, conservative farmers were found to be older (60 years-old on average) and had more experience in crop management (they had grown corn since 1971). This group of farmers used 82.5% of corn production for sales, as they used the remaining percentage for their own consumption. Most of them used creole seeds with lower yields, implemented smaller crops, and had to travel a longer distance from their homes to their fields. These decision-makers were shown to be risk averse, where family members represented the main source of information they take into consideration. Thus, on the informational level, our results showed that an effective extension system fostered farmer capacity, giving them access to information that can reduce uncertainty about the possible results of using new technology, as also noted by Feder et al. (1985). For this reason, it is important that research, extension, and agricultural education work together to allow farmers to understand and appreciate the characteristics of new varieties (Rivera & Romero, 2003).

Table 12. Average values of the key variables for the different corn farmer groups in Chiapas, Mexico

Segments	Innovators	Transition farmers	Conservative
Seed used	Improved seed^{a}	Both seeds^{b}	Creole^{c}
Age (in years)	52^{b}	58^{b}	60^{a}
Number of generations in agriculture	3^{a}	3^{a}	2^{b}
Number of generations growing corn	3^{a}	4^{a}	2^{b}
Starting year of managing Crop	1983^{a}	1980^{ab}	1972^{b}
Starting year growing corn	1980^{a}	1981^{a}	1971^{b}
Assessment of soil quality	7.6^{a}	6.9^{b}	7.6^{a}
Corn sales (%)	93.5^{a}	89.6^{b}	82.5^{b}
Total surface (ha)	5.2^{a}	4.7^{a}	3.4^{b}
Yield (tha^{-1})	4.2^{a}	3.7^{a}	2.9^{b}
Quantity sold (kg.ha^{-1})	21356^{a}	15816^{ab}	5635^{b}
Distance from crops to farmer home (km)	5.3^{a}	3.9^{a}	7.5^{b}
Improved seed acceptance	Positive^{a}	Intermediate^{a}	Negative^{b}
Willingness to take risks	Take it^{a}	Intermediate^{ab}	Averse^{b}
Source of information used	Technicians of commercial establishments^{a}	Employees^{a}	Family Members^{b}

3.5 Conclusions

The increase of corn productivity is the fundamental challenge for growers who work non-irrigated land in Mexico. Improved seeds, together with technological innovations at the farm level, can substantially improve productivity that may help satisfy the national demand, as well as improve living conditions and sustainability for farmers in rural areas. Therefore, it is essential to increase the adoption rate of improved corn seeds. The low adoption rate of improved seeds in the area is mainly due to the high cost of the seeds and the fact that improved varieties are designed without the farmers' opinions and real needs taken into consideration. This negligence can lead to varieties that lack the attributes preferred by farmers. Our results confirmed that the decision to adopt improved corn varieties is mainly based on WTP for several different attributes; thus, it is important to first define farmer preference and WTP for corn attributes and then design varieties that meet their requirements.

The application of the DCE and the GMNL in the WTP-space approach showed that farmers in the analyzed area preferred a high-yield variety, resistance to diseases, and corn with bigger cob size. Farmers are willing to adopt a variety only if it includes attributes that represent their preferences. Results also implied that the improvement of crops and the adoption of the improved varieties in these communities might be feasible. This improvement can be done through farmers' participation in the process of generation and selection of seeds to ensure that their priorities and needs are incorporated into the existing local varieties, or the creation of new ones. Regarding the preference heterogeneity analysis, results showed that farmers in Chiapas are grouped into three segments and differentiated according to their preferences for improved seeds. The advanced age of the conservative producers, combined with a low level of education and the small area available for planting, are limiting factors for the adoption of technological innovations and the productive growth of corn. The conservative and transitional regional producers are still unaware of the economic benefits of improved varieties, their availability, and accessibility. For this reason, we highlight the importance of redirecting extensions in Mexico to make it more efficient and effective in order to publicize the benefits. A more intensive program of demonstrations and tests at the farm level is justifiable for farmers in transition and conservative categories. On the other hand, for the group of innovators, it is necessary to focus on improving the availability of better seeds.

Although in the last twenty years there have been many changes and institutional innovations in the system of agricultural research and extension in Mexico, these have not been sufficient. Our analysis clearly indicates that most farmers have had limited contact with the extension system. This limitation contributes to a negative perception of the use of improved seeds. Furthermore, we found that farmers are only familiar with improved seed distributed through transnational corporations. In our sample of farmers, none were aware of the possibility of purchasing improved seeds produced by government institutions. Similarly, it is important to mention that our conclusions relate only to the case study analyzed in the state of Chiapas. To be able to reach further conclusions, we recommend extending these analyses to other corn- producing states. These analyses would provide comparisons that would be helpful in understanding the variation of demand for corn attributes, as well as the heterogeneity of social preferences.

Future research should consider a deeper evaluation of the attitudes towards risk and a detailed assessment of the system's expansion in Mexico. Additional research is also needed to assess impact evaluations of programs of improvement of maize in Mexico. These results confirm the need to design differentiated agricultural policies, at the local level, that take into account the different groups and preferences. However, the lack of such policies regarding the adoption of agricultural technologies and improved varieties in Mexico represent one of the challenging issues for agricultural authorities. In this way, our study contributes to the planning of further research, validation, transference, and adoption of future technologies. Moreover, future application of the choice experiment to the design and targeting of modern crop varieties should carefully consider sample composition and size to permit the estimation of relevant sub-models for desired farmer segments. Finally, the reduction of investment in agricultural research in Mexico is likely to worsen the disparity between rural and urban life. Agricultural research can potentially improve rural livelihoods, uniquely addressing farmers' problems and allowing for a generation of more efficient technologies.

3.6 References

Ajambo, R., Bashaasha, B., Okori, P., Elepu, G. (2010). Producer and consumer preferences for maize and sorghum quality characteristics in Uganda. In *In Second RUFORUM Biennial Regional Conference on" Building capacity for food security in Africa". RUFORUM* (pp. 1627–1631). Entebbe, Uganda.

Asrat, S., Yesuf, M., Carlsson, F., Wale, E. (2010). Farmers' preferences for crop variety traits: Lessons for on-farm conservation and technology adoption. *Ecological Economics*, 69(12): 2394–2401.

Bastell, R., Louviere, J. (1991). Experimental analysis of choice. *Marketing Letters*, *2*(3): 199–214.

Bellon, M. (1991). The ethnoecology of maize variety management: A case study from Mexico. *Human Ecology*, 19(3): 389–418.

Bellon, M., Adato, M., Becerril, J., Mindek, D. (2006). Poor farmers' perceived benefits from different types of maize germplasm: The case of creolization in lowland tropical Mexico. *World Development*, 34(1): 113–129.

Bellon, M., Risopoulos, J. (2001). Small-Scale Farmers Expand the Benefits of Improved Maize Germplasm: A Case Study from Chiapas, Mexico. *World Development*, 29(5): 799–811.

Ben-Akiva, M., Lerman, S. (1985). Discrete choice analysis: theory and application to travel demand. *MIT Press., 9*.

Benz, B., Perales, H., Brush, S. (2007). Tzeltal and Tzotzil Farmer Knowledge and Maize Diversity in Chiapas, Mexico. *Current Anthropology*, 48(2): 289–300.

Bernard, M., Hellin, J., Nyikal, R., Mburu, J. (2010). Determinants For Use Of Certified Maize Seed And The Relative Importance Of Transaction Costs. In *Joint 3rd African Association of Agricultural Economists and 48th Agricultural Economists Association of South Africa Conference. Cape Town, South Africa.* (p. 26).

Birol, E., Smale, M., Gyovai, A. (2006). Using a Choice Experiment to Estimate Farmers' Valuation of Agrobiodiversity on Hungarian Small Farms. *Environmental & Resource Economics*, 34: 439–469.

Birol, E., Smale, M., Yorobe, J. (2012). Bi-modal preferences for bt maize in the Philippines: A latent class model. *AgBioForum*, 15(2): 175–190.

Birol, E., Villalba, E. (2006). Estimating Mexican Farmers' Valuation of Milpa Diversity and Genetically Modified Maize: A Choice Experiment Approach. *Nvironmental Economy and Policy Research Working Papers*, 21.

Birol, E., Villalba, E., Smale, M. (2009). Farmer preferences for milpa diversity and genetically modified maize in Mexico: a latent class approach. *Environment and Development Economics*, 14(04): 521–540.

Castillo, J., Chávez, C. (2013). Caracterización campesina del manejo y uso de la diervisad de maíces en San Felipe del Progreso, estado de México, 10(1): 23–38.

ChoiceMetrics. (2014). *Ngene 1.1.2 User Manual and Reference Guide*. Australia. 667p.

Copeland, O., McDonald, M. (2001). Principles of seed science and tchnology. (K. academic Publishers, Ed.) (4th ed.). Massachusetts, USA: luwer Academic Publishers. 390p.

Dhar, R., Simonson, I. (2003). The Effect of Forced Choice on Choice. *Journal of Marketing Research*, 40(2): 146–160.

Estrada, B., Martínez, V., Vázquez, C., González, M. (2015). Características eloteras y de grano de variedades nativas de maíz de Chiapas. *Revista Mexicana de Ciencias Agrícolas*, 6(5): 1119–1127.

FAOSTAT. (2016). Organización de las naciones unidas para la alimentación y la agricultura (FAO). *Accessed July 2016, available at http://faostat.fao.org*. doi:Accessed July 2016, available at http://faostat.fao.org

Feder, G., Just, R., Zilberman, D. (1985). Adoption of agricultural innovations in developing countries: A survey. *Economic Development and Cultural Change*, 33(2): 55–298.

Ferro, E., Chirino, E., Márquez, M., Mirabal, E., Ríos, H., Guevara, F., Alfaro, F. (2013). Experiencias obtenidas en el desarrollo participativo de híbridos lineales simples de maíz (Zea mays, L.) en condiciones de bajos insumos agrícolas. *Cultivos Tropicales*, 34(2): 61–69.

Ferro, M., Ríos, H., Chirino, E., Márquez, M., Valdés, R. J., Suárez, Y., Alfaro, F. (2008). Entendiendo el sistema informal de semilla de maíz cubano. La selección de variedades de máiz (Zea mays, Lin) por campesinos de La palma, Pinar del Rio. *Cultivos Tropicales*, 29(1): 61–68.

Fiebig, G., Keane, P., Louviere, J., Wasi, N. (2010). The Generalized Multinomial Logit Model: Accounting for Scale and Coefficient Heterogeneity. *Marketing Science*, 29(3): 393–421.

Gecho, Y., Punjabi, N. K. (2011). Determinants of adoption of improved maize technology in Damot Gale, Wolaita, Ethiopia. *Rajasthan Journal of Extension Education*, 19(1): 1–9.

Greene, H., Hensher, A. (2010). Does scale heterogeneity across individuals matter? An empirical assessment of alternative logit models. *Transportation*, 37(3): 413–428.

Greene, W., Hensher, D. (2003). A latent class model for discrete choice analysis: contrasts with mixed logit. *Transportation Research Part B: Methodological*, 37(8): 681–698.

Hanley, N., Wright, R., Adamowicz, V. (1998). Using Choice Experiments to Value the Environment. *Environmental and Resource Economics*, 11(3-4): 413–428.

Hellin, J., Bellon, M. (2007). Manejo de semillas y diversidad del maíz — AgriCultures Network. *LEISA Revista de Agroecología*, 23(2): 9–11.

Hellin, J., Bellon, M., Badstue, L. (2006). Reduciendo la brecha entre la realidad de los investigadores y la de los agricultores — AgriCultures Network. *LEISA, Revista de Agroecología*, 22: 5– 8.

Hellyer, E., Fraser, I., Haddock-Fraser, J. (2012). Food choice, health information and functional ingredients: An experimental auction employing bread. *Food Policy*, 37(3): 232–245.

Herrera, E., Macías, A., Díaz, R., Valadez, M., Delgado, A. (2002). Uso de semilla criolla y caracteres de mazorca para la selección de semilla de maíz en México. *Rev. Fitotecnia Mexicana*, 25(1): 17–23.

Hirpa, A., Meuwissen, M., Van der Lans, A., Lommen, M., Oude Lansink, M., Tsegaye, A., Struik, C. (2012). Farmers' Opinion on Seed Potato Management Attributes in Ethiopia: A Conjoint Analysis. *Agronomy Journal*, 104(5): 1413–1424.

Howley, P., Buckley, C., O Donoghue, C., Ryan, M. (2015). Explaining the economic "irrationality" of farmers' land use behaviour: The role of productivist attitudes and non-pecuniary benefits. *Ecological Economics*, 109: 186–193.

Hu, W., Hunnemeyer, A., Veeman, M., Adamowicz, W., Srivastava, L. (2004). Trading off health, environmental and genetic modification attributes in food. *European Review of Agricultural Economics*, 31(3): 389–408.

INEGI. (2015). Encuesta Nacional Agropecuaria ENA 2014. Resultados. *http://www.inegi.org.mx/est/contenidos/proyectos/encuestas/agropecuarias/ena/ena2014/doc/pre sentacion/ena2014_pres.pdf. (Accessed July 2016).* Retrieved from Accessed July 2016, available at http://www.inegi.org.mx/est/contenidos/proyectos/encuestas/agropecuarias/ena/ena2014/doc/pre sentacion/ena2014_pres.pdf.

Kalinda, T., Tembo, G., Kuntashula, E. (2014). Adoption of Improved Maize Seed Varieties in Southern Zambia. *Asian Journal of Agricultural Sciences*, 6(1): 33–39.

Kallas, Z., Gómez-Limón, J. (2007). Agricultural Multifunctionality Valuation : A Case Study Using The Choice. *Estudios de Economía Aplicada*, 25(1): 107–144.

Kallas, Z., Serra, T., Gil, J. (2010). Farmers' objectives as determinants of organic farming adoption: the case of Catalonian vineyard production. *Agricultural Economics*, 41(5): 409–423.

Kassie, G., Abdulai, A., MacRobert, F., Abate, T., Shiferaw, B., Tarekegne, A., Maleni, D. (2014). Willingness to pay for Drought Tolerance (DT) in Maize in Communal Areas of Zimbabwe. 88th Annual Conference, April 9-11, 2014, AgroParisTech, Paris, France.

Kyeyune, V., Turner, S. (2016). Yielding to high yields? Critiquing food security definitions and policy implications for ethnic minority livelihoods in upland Vietnam. *Geoforum*, 71: 33–43.

Li, J., Lammerts, E., Jiggins, J., Leeuwis, C. (2012). Farmers' adoption of maize (Zea mays L.) hybrids and the persistence of landraces in Southwest China: implications for policy and breeding. *Genetic Resources and Crop Evolution*, 59(6): 1147–1160.

Lockshin, L., Jarvis, W., D'Hauteville, F., Perrouty, J. (2006). Using simulations from discrete choice experiments to measure consumer sensitivity to brand, region, price, and awards in wine choice. *Food Quality and Preference*, 17(3-4): 166–178.

Louviere, J. (1981). Laboratory simulation vs. revealed preference methods for estimating travel demand models: an empirical comparison. *Transportation Research Record*, 794: 42–51.

Louviere, J. (2001). Choice experiments: an overview of concepts and issues. In R. Bennett, J. y Blamey (Ed.), *The Choice Modelling Ap- proach to Environmental Valuation.* (Edward Elg., pp. 1–36). UK.: Cheltenham, UK : E. Elgar Pub.

Luna, M., Hinojosa, A., Ayala, O., Castillo, F., Mejía, A. (2011). Perspectivas de desarrollo de la industria semillera de maíz en México. *Revista Fitotecnia Mexicana*, 35(1): 1–7.

Lusk, L., Roosen, J., Fox, A. (2003). Demand for Beef from Cattle Administered Growth Hormones or Fed Genetically Modified Corn: A Comparison of Consumers in France, Germany, the United Kingdom, and the United States. *American Journal of Agricultural Economics*, 85(1): 16–29.

Makokha, S., Karugia, J., Stall, S., Oluoch, W. (2007). Valuation of cow attributes by conjoint analysis: A case study of Western Kenya. *Afjare*, 1(2): 1–19.

Martínez, M., Ríos, H., Miranda, S., Moreno, I., Acosta, R., Farrera, A., Velasco, J. (2006). Caracterización de la diversidad y selección participativa de prospecciones de maíz en Chiapas, México. *Cultivos Tropicales*, 27(1): 55–62.

Meas, T., Hu, W., Batte, M., Woods, T., Ernst, S. (2015). Substitutes or Complements? Consumer Preference for Local and Organic Food Attributes. *American Journal of Agricultural Economics*, 97(4): 1044–1071.

Morris, L., Bellon, M. (2004). Participatory plant breeding research: Opportunities and challenges for the international crop improvement system. *Euphytica*, 136(1): 21–35.

Paredes, C., Martin, A. (2007). Adoption of Transgenic Crops by Smallholder Farmers in Entre Rios, Argentina. American Agricultural Economics Association (New Name 2008: Agricultural and Applied Economics Association).

Rivera, A., Romero, H. (2003). Evaluación del nivel de transferencia y adopción de tecnología en el cultivo de caña de azúcar en Córdoba, Veracruz, México. *Avances en la investigación agropecuaria*, 21(2): 20–40.

Roessler, R., Drucker, A., Scarpa, R., Markemann, A., Lemke, U., Thuy, L., Valle, A. (2008). Using choice experiments to assess smallholder farmers' preferences for pig breeding traits in different production systems in North–West Vietnam. *Ecological Economics,* 66(1): 184–192.

Salgado, V., Miranda, G. (2010). El mercado de semilla mejorada de maíz por entidad federativa. *Economía Actual,* 3(1): 10–12.

Scarpa, R., Drucker, A., Anderson, S., Ferraes, N., Gómez, V., Risopatrón, C., Rubio, O. (2003). Valuing genetic resources in peasant economies: the case of "hairless" creole pigs in Yucatan. *Ecological Economics*, 45(3): 427–443.

SIAP. (2016). Avances de Siembras y Cosechas por Estado y Año Agrícola. Secretaría de Agricultura, Ganadería, Desarrollo Rural, Pesca y Alimentación. Accessed March 2016. *Accessed March 2016* in http://www.gob.mx/siap/

Sibiya, J., Tongoona, P., Derera, J., Makandaa, I. (2013). Farmers' desired traits and selection criteria for maize varieties and their implications for maize breeding: A case study from Kwazulu-Natal Province, South Africa. *Journal of Agriculture and Rural Development in the Tropics and Subtropics*, 114(1): 39–49.

Soleri, D., Cleveland, D. (2001). Farmers' genetic perceptions regarding their crop populations: An example with maize in the central valleys of Oaxaca, Mexico. *Economic Botany*, 55(1): 106–128.

Spielman, D. J., Davis, K., Negash, M., Ayele, G. (2011). Rural innovation systems and networks: findings from a study of Ethiopian smallholders. *Agric. Hum. Values*, 28: 195–212.

Train, K., Weeks, M. (2005). Discrete choice models in preference space and willingness-to-pay space. (S. Netherlands, Ed.). In Applications of simulation methods in environmental and resource economics (pp. 1-16).

Tudela, J. (2010). Experimentos de elección en la priorización de políticas de gestión en Áreas Naturales Protegidas. *Revista Desarrollo Y Sociedad*, 66: 83–218.

Turrent, A., Wise, T., Garvey, E. (2012). El municipio en Chiapas en la coyuntura zapatista: un actor inesperado. Mexican Rural Development Research Reports. No. 16. 32 p.

Valdivia, R., Espinosa, A., Tadeo, M., Caro, F., Aguilar, J., Vidal, V., … López, G. (2015). “Cora 2012”: híbrido intervarietal de maíz para Nayarit y regiones similares. *Revista Mexicana de Ciencias Agrícolas*, 6(2): 417–420.

Windle, J., Rolfe, J. (2005). Diversification choices in agriculture: A choice modelling case study of sugarcane growers. *The Australian Journal of Agricultural and Resource Economics*, 49(1): 63–74.

Wu, L., Wang, S., Zhu, D., Hu, W., Wang, H. (2015). Chinese consumers’ preferences and willingness to pay for traceable food quality and safety attributes: The case of pork. *China Economic Review*, 35: 121–136.

THIRD PAPER: DETERMINANT FACTORS OF THE ADOPTION OF IMPROVED MAIZE SEEDS IN SOUTHERN MEXICO: A SURVIVAL ANALYSIS APPROACH

UNDER REVIEW: TECHNOLOGICAL FORECASTING & SOCIAL CHANGE

CHAPTER 4

DETERMINANT FACTORS OF THE ADOPTION OF IMPROVED MAIZE SEEDS IN SOUTHERN MEXICO: A SURVIVAL ANALYSIS APPROACH

Corn is the most important and strategic crop in Mexico; however, its sector suffers from low productivity. Among the various strategies to improve yield by hectare, improved maize seeds play an important role. In this context, the adoption studies in Mexico of these types of seeds are still scarce and in general do not include the analysis of the determinant factors affecting their rate of adoption. This study analyzes the determinants of adoption rates of improved seeds using the survival analysis method. Farm-level data was collected in 2015 through a questionnaire administered to 200 maize farmers in Chiapas, Mexico. Our results show that approximately the decision of the 60% of farmers who adopted was over a period of 10 years. *Specifically, young farmers with low family members from several generations of agricultural work who exhibited positive attitudes towards innovation and low risk perception are likely to adopt the new varieties. Furthermore, results show that the NAFTA Mexican reform of agricultural policy in 1994 negatively affected the adoption rate of improved seeds. Improving the maize yield requires adequate extension information systems that allow farmers to receive more information on the importance of adoption innovation, as well as help them in marketing their products*.

4.1 Introduction

The globalization and liberalization of food markets as well as the agriculture sector in particular have created a scenario in which the predominant position is to achieve food security from comparative and competitive advantages. In light of this, Mexico has resorted to importing corn (10.7 million tonnes in 2015) (SIAP, 2016), thereby increasing food dependency. Notably, one consequence of this food dependency is increasing poverty hunger (extreme poverty) (Camberos, 2000). To improve and ensure Mexican food security policy, corn production in country should increase to meet the increasing demand for corn. This strategy is particularly relevant when the reduction of arable land due to population growth is taken into consideration. Accordingly, increasing productivity through the adoption of the technological innovation is fundamental in mediating these issues. Maize production is carried out mostly in non-irrigated lands by small producers (less than five hectares) and low yields. Turrent et al. (2012) estimated that the potential for maize production in Mexico is 52 million tonnes, of which 28 million would be feasible to achieve in the short term. This short-term increase could be reached without increasing the amount of agricultural land used and without cultivating transgenic maize. Therefore, increasing maize production and yields is a feasible option under non-irrigated conditions, especially through the adoption of improved seeds (Schroeder et al. 2013).

The maize seed improvement in Mexico in the last fifty years is one of the most studied topics in agricultural research, partnered with the objective to increase its adoption. A number of hybrids and open-pollinated varieties (OPVs) have been developed and disseminated for boosting production under various environmental conditions. Luna et al. (2012) note that the first improved maize varieties were developed in 1947 and by 1950, 23 varieties of maize had already been released. Nevertheless, acceptance of the improved seeds remains low amongst farmers, particularly small farmers. The planted area only represents 2.7 million hectares of a total of 6.1 million hectares of total production in Mexico (Rodríguez et al. 2015). To illustrate, the state of Chiapas has the largest demand for corn seed and the highest potential for increasing production; however, it is still one of the states with the lowest adoption rates of improved seeds (30%), due to the low-perceived advantage of this technology (SIAP 2016). Furthermore, there are a wide range of factors that may affect the ability of farmers to adopt technologies at the farm level such as socio-economical, institutional, cultural, and political conditions and variables (Beyene & Kassie, 2015). The price of the seed and the cost of innovation are key factors at play in the adoption of improved seeds in Mexico. Nevertheless, there is evidence that small-scale farmers are willing to use improved seed if it clearly increases yields and if innovations are affordable, as shown in studies in El Salvador, Zimbabwe, China, and Kenya (López & Filipello, 1994).

The success of research and the development of innovation usually occur when farmers make an effective use of technology. CIMMYT (1993) note that all institutions involved in the generation and the transfer of agricultural technology must be able to design and conduct studies that clearly identify the adoption rate and explain the motivations and determinant factors of farmers. Although several studies have examined the adoption and diffusion of new varieties, these studies are limited to determining the rate of adoption and the factors that affect the decisions at a given time, in general, through static analysis based mainly on Probit, Logit, or Tobit models (Ghadim et al. 2005). The length of time, or duration, farmers wait before adopting a new technology may be expected to depend on a number of economic, social and institutional factors, some of which vary with time (for example, the age of the farmer and major reform) and some of which do not (for example, sex of farmer, education level). This paper examines the adoption behavior over time of improved maize seeds of smallholder farmers in the Chiapas, Mexico using duration analysis, a statistical technique which provides numerical and graphical summaries of duration data and allows the researcher to investigate the effects of explanatory variables on the duration of stay of an individual in a given state. Duration analysis, therefore, allows us to determine not only why farmers adopted improved maize seeds, but also when they adopted and what factors influenced the observed time patterns. In addition, within the advantages of survival analysis, it can be mentioned that this analysis can be performed even when the population is heterogeneous, and in data where censored information exists (in the usual techniques incomplete data are discarded) (Klein and Moeschberger, 2003). To date, few studies have used the survival analysis in Mexican agriculture. Hattam et al. (2012) analyzed organic adoption decisions using a rich set of time-to-organic durations collected from avocado small-holders in Michoacán Mexico. In this context, analysis of the adoption behavior of maize seed farmers with this method is still scarce.

Thus, our work contributes to previous literature by extending a survival analysis to consider farmer attitudes and risk perceptions as relevant factors in explaining the decision to adopt. In this regard, attitudes and preferences are important determinants of adoption decisions (De Cock, 2005). To capture and simplify this complexity, we use the Principal Components Analysis (PCA); the resulting factors from PCA are used as explanatory variables of improved seed adoption. Furthermore, the research is expected to provide the foundation for greater efficiency of agricultural policies, as well as help generate and transfer technologies. Importantly, a better understanding of the underlying dynamics the adoption may help improve strategies to accelerate adoption.

4.2 Materials and methods

4.2.1 Study area

Maize is the most dominant crop of southern Mexico, where the highest rates of extreme poverty and subsistence agriculture are concentrated (King, 2007). The state of Chiapas is located in the south-eastern tip of the country bordering Guatemala; it has an area of over 70,000 square kilometers and has the highest poverty, extreme poverty, and marginalization rates. The percentage of the population in poverty is 76.2%, which is equivalent to 3,961 millions of people in this condition (CONEVAL, 2016).

Chiapas has the largest acreage of corn in Mexico, but obtaining this grain has become no longer profitable. During 2015, 609,000 hectares were planted, with an average yield of 1.6 tha^{-1} (SIAP, 2016). The low productivity of corn in the state is due to marginal soils, low economic capacity of farmers to implement basic inputs, mechanization of cultivation, and use of landraces.

4.2.2 Methodological framework

The collected data were analyzed through survival analysis, which is a set of statistical-econometric procedures whose main objective is the study of the length of time until an event of interest occurs time. In the context of technology adoption, this transition lasts from the time the technology is known until the adoption becomes effective. It is built as a model of behavior, in which individual choices are modeled using cross-sectional data, incorporating dynamic elements for adoption (Bekele & Abebe, 2014).

The use of survival analysis is appropriate considering it is quite strong compared to other methods. Some advantages of the use of survival analysis over the classical techniques such as logit model estimation, regression, or discriminant analysis are inclusion in the model of the explanatory constants and variables in time, as well as the circumstance variation over time (Bekele & Abebe, 2014).

In comparison to the traditional static method (logit, probit, tobi), survival analysis analyzes both the diffusion and the adoption aspect of technology. The survival analysis has the advantage of explaining not only what individuals adopt, but also how long they have taken to make it, offering the possibility to explore alternative specifications for the diffusion curve S form (Abdulai & Huffman, 2005). The first application in economics was conducted by Lancaster (1978) who analyzed the duration of unemployment. At the agriculture sector, the survival analysis was applied in several studies such as the adoption of conservation tillage (D'Emden et al. 2006), improved seed (Bekele and Abebe 2014; Beyene and Kassie 2015; Fujiie et al. 2010; Matuschke and Qaim 2008; Nazli and Smale 2016), sustainable technology adoption (De Souza et al. 1999), greenhouses (Alcon et al. 2010), organic agriculture (Läpple 2010), adoption of cross-bred cows (Abdulai & Huffman, 2005), adoption of fertilizer and herbicide (Dadi and Ozanne 2004), and drip irrigation (Alcon et al. 2011). Let T be a nonnegative random variable that measures the length of a spell (the adoption of improved seed). Also consider t as a realization of (T) where the observed durations of each subject consist of a series of data $(t_1 < t_2 < \cdots t_n)$. Let $f(t)$ be a continuous probability distribution function (PDF) of T. The probability distribution of the duration variable can be specified by the cumulative density function (CDF) (Lawless 1982, Lancaster 1992).

$$F(t) = \int_0^t f(s)ds = \Pr(T \leq t) \quad (1)$$

Equation (1) is the probability of T to be smaller than a value t. Nevertheless, researchers are interested in the probability that T has a length of at least t. This probability is given by the survival function as:

$$S(t) = P(T > t) = 1 - F(t) \quad (2)$$

The probability that the duration of adoption occurs in an infinitesimal time period Δt after time t (given that the non-adoption decision has lasted up to t is:

$$P(t \leq T < t + \Delta \mathrm{t} | \mathrm{T} > t) \quad (3)$$

In a further step, the hazard function $h(t)$ is defined as the probability that a farmer adopts the improved seeds at time t (i.e. $T = t$), given he has not adopted it before t.

$$h(t) = \lim_{\Delta \mathrm{t} \to 0} \frac{P(t \leq T < t + \Delta \mathrm{t} | \mathrm{T} > t)}{\Delta \mathrm{t}} = \frac{f(t)}{S(t)} \quad (4)$$

The hazard function can be further mathematically expressed as follows,

$$h(t) = \frac{f(t)}{S(t)} = \frac{dF(t)/dt}{S(t)} = \frac{-dS(t)/dt}{S(t)} = \frac{-dlnS(t)}{d(t)} \quad (5)$$

In addition to the length of duration time of adoption, a set of explanatory variables may affect the distribution of the duration. This means that the $h(t)$ should be respecified and redefined as follows (Lancaster 1992):

$$h(t, \boldsymbol{x}, \boldsymbol{\theta}, \boldsymbol{\beta}) = \lim_{\Delta \to 0} \frac{\Pr\,(t \leq T < t + \Delta | T \geq t)}{\Delta} \qquad (6)$$

Where $\boldsymbol{\beta}$ is a vector of unknown parameters of $\boldsymbol{x}$, the vector of explanatory variables, which may include time-invariant and time-varying variables, and $\boldsymbol{\theta}$ is a vector of parameters that characterize the distribution function of the hazard rate.

After the inclusion of the explanatory variables, the hazard function $h(t, \boldsymbol{x}, \boldsymbol{\theta}, \boldsymbol{\beta})$ can be split into two components. The first component is the part of hazard that depends on subject characteristics $g(\boldsymbol{x}, \boldsymbol{\beta})$. The second one is the baseline hazard function $h_0(t)$, which is equal to the hazard when all covariates are zero. Notably, the latter one does not depend on individual characteristics; this component captures the way the hazard rate varies in duration. In this context, the shape (distribution function) of the hazard function has important implications for duration dynamics. In our case study, the non-parametric method of the Kaplan-Meier (KM) estimator (Bland & Altman, 1998) was used to explore the covariates effects and the potential distribution to be used if the parametric approach is applied. The KM estimator produced an empirical approximation of survival and hazard, which is similar to an exploratory data analysis; denoting the distinct failure times of individuals as $t_1 < t_2 < \cdots t_n$.

In our study, the semiparametric Cox proportional hazards model (Cox, 1972) was used to estimate the survival data and explain the effect of explanatory variables on hazard rates. This model was used because of its better fit (Lawless 1982), robustness (Allison, 1982), and no assumptions of any previous distribution and shape of the hazard function. Under the Cox proportional hazards model, the duration of each farmer is assumed to follow its own hazard function $h_i(t)$ which can be expressed as:

$$h_i(t) = h(t; x_i) = h_0\,(t) \exp(x_i^{\prime} \beta) = h_0(t) \exp(\beta_1 \mathrm{x}_{i1} + \cdots + \beta_1 \mathrm{x}_{i1}) \text{ thus,}$$

$$\log h_i\;(t) = \propto (t) + \beta_1 x_{i1} + \cdots + \beta_k x_{ik}$$

where $\propto (t) = \log h_0\;(t)$ and β are the proportional effects of **x** on the probability of improved seed adoption. The estimation procedure is based on the partial likelihood function; more details are available in Cox (1972). The estimation was performed by R software version 3.3 survival package.

4.2.3 Empirical application

Data was collected from a sample of 200 farmers in a face-to-face survey at the farm level during January and March of 2015. The sample was stratified by seed variety (creole and improved) and different regions (Villaflores, Chiapas de Corzo, Villacorzo, and La Concordia) with high production level of maize production in Chiapas. Farmers were selected randomly using the registration information in the Programa de Apoyos Directos al Campo (PROCAMPO)[1], which represents 98% of total corn farmers SIAP (2016). For the empirical application of the survival analysis, first, the dependent variable that represents the last time to decide adoption the innovation or the technology was identified. In our case study, the start date was set as the year in which the farmer is responsible for cultivating corn. Additionally, the end period was the year in which the farmer adopted the technology of the improved seeds of maize. For those who had not adopted the technology when the study was conducted, their end year was set as a censored value. Although adoption could take place in the future, for these cases, the statistical procedure of the time variable was censored on the right with the date on which the survey was established as final data.

Regarding the independent variables, according to literature the decision of adoption may depend on a broad set of determinant factors that include: features of innovation and policy, expectations of farmers, farm structure, and the socio-economic environment (Feder & Umali, 1993), as well as behaviors, attitudes, and opinions toward innovation and risk. According to the studies reviewed, the most important factors that influence decision making in agriculture are:

1) ***Farmer Characteristics (F)***: gender, education, age, experience, etc.,(Bekele and Abebe 2014; Mwangi et al. 2015).
2) ***Farm structure (S):*** location, farm size, production system, irrigation method, labor, machinery, maize varieties used (Alcon et al. 2011; Dhakal et al. 2015; Islam et al. 2015).
3) ***Farm Economic data(EC):*** revenue and production costs, access to credit (Kallas et al. 2010; Smale and Howard 1994).
4) ***External factors (E):*** external factors like media contact, technical assistance, agricultural policies, government programs, access and overtures to universities or research institutions (Weber & McCann, 2015).

[1] A program that promotes and finances agriculture activities in the regions of this study.

5) ***Farm management and results (M):*** aspects such as performance and productivity (Asfaw et al. 2012; Ghimire et al. 2015).
6) ***Attitudes and risk perceptions (A):*** aspects such as resistance to change and interest in technological innovation (De Cock 2005; Kallas et al. 2010).

Attitudes and risk perceptions play an important role as determinants of the adoption of improved seeds (Cavallo et al. 2014; Howley et al. 2015; Kallas et al. 2010; Nandi et al. 2015), and they were presented in different constructs including various measured items in a Likert scale from zero to 10, where zero indicated that the farmer was strongly disagree with the claims submitted and 10 was strongly agree. Identified affirmations were discussed and analyzed in a discussion group formed by various researchers involved in the study. The information contained in the constructs were validated and reduced through the Confirmatory Principal Component Analysis (PCA) following (Hair et al. 1998). The variables used are presented in Table 13 with the corresponding reference, and the factors resulting from PCA were used as explanatory covariates adoptions of improved maize seeds.

Table 13. Variables on attitudes and preferences used in the study

Attitudinal variables	References
The sale of improved maize prices to cover the higher production costs	(Valdivia et al. 2015)
Planting corn with improved seeds can ensure the future of farms	(Valdivia et al. 2007)
Seeding with improved maize seeds contributes to a positive image for the exploitation	(Valdivia et al. 2007)
Planting improved seeds with increased household income	(Hellin & Bellon, 2007)
Improved maize seeds have better market acceptance	(Hellin and Bellon 2007)
The masa-tortilla relationship is greater with the improved seeds	(Salazar et al. 2015)
Risk variables	
Risk from marketing is less with improved seeds	(Birol et al. 2012)
The risks from proliferation of pests and diseases are lower with improved seeds	(Li et al. 2012; Smale et al. 1994)
There is less risk for lending to farmers with improved seeds	(Li et al. 2012; Smale et al. 1994)
The risk from fluctuation is lower yields improved seeds	(Sibiya et al. 2013; Veisi et al. 2016)
The risk from drought is less with improved seeds	(Veisi et al. 2016; Asrat et al. 2010; Kamara et al. 2006)
The risk of losses due to frost is less with improved seeds	(Asrat et al. 2010; Veisi et al. 2016)

We also included a dummy variable representing the impact of agricultural reform, specifically, the Free Trade Agreement with North America (NAFTA). Trade liberalization launched in 1994, reinforcing the role of transnational agribusiness that supported the dissemination of technological packages, improved seeds, and herbicides and chemical fertilizers through subsidies or production campaigns (Fox & Haight, 2010). Accordingly, the variable has a value of one if the farmer adopted improved seeds after the entry into NAFTA, and zero otherwise. Furthermore, economic liberalization formally began when Mexico signed the General Agreement on Custom Duties and Trade (GATT) in 1986. Mexico also went through various internal reforms. Since the mid-thirties to early nineties, the Mexican grain sector was supported by the Government through the National Company of Popular Subsistence (Conasupo). In 1999, this company was shut down and government involvement in the sector was reduced to the retail sale of grain through DICONSA network, the allocation of imports of maize, and the Kilo for Kilo program. The Kilo for Kilo program was a tool for technological induction, for producers to use improved seeds. Payments by the Rural Support Program (PROCAMPO) was introduced in 1994. It consists in transferring direct income to farmers who produce basic crops, including corn. Transfers are made per hectare and are independent of productivity. Since 1991, the controlled Support to Commercialization program (ASERCA) provides support for the commercialization of some basic crops in regions with surpluses. The Rural Alliance program was created in 1995. Its main objective was to increase agricultural productivity and provide farmers with funds for investment and health projects. In short, PROCAMPO, ASERCA and the Rural Alliance were created as transition policies so that producers would face foreign competition and to transform the structure of agricultural production in Mexico (Yúnez & Barceinas, 2004).

4.3 Results and discussion

4.3.1 Descriptive analysis of hypothetical variables

The confirmatory PCA results indicate that a single factor (potential acceptance of improved corn seeds) explains 68% of the variability in the original variables, with accepted goodness of fit measures. In this same line, another factor regarding the risk aversion behavior was estimated with 56% of variability explanation (Table 14).

Table 14. Confirmatory results of the PCAs on farmers' attitudes and risk behavior

Variables	Confirmatory factor: Potential acceptance of improved corn seeds
The sale of improved maize prices to cover the higher production costs	0.85
Planting corn with improved seeds can ensure the future of farms	0.84
Seeding with improved maize seeds contributes to a positive image for the exploitation	0.83
Planting improved seeds with increased household income	0.82
Improved maize seeds have better market acceptance	0.81
The masa-tortilla relationship is greater with the improved seeds	0.77
Cronbach' Alfa: 0.882, KMO: 0.839, Bartrlet Test: 774.32 (0.000, explained variance: 68%, rotation method: Varimax	

Variables	Confirmatory factor: Risk aversion
Risk from marketing is less with improved seeds	0.87
The risks from proliferation of pests and diseases are lower with improved seeds	0.82
There is less risk for lending to farmers with improved seeds	0.81
The risk from fluctuation is lower yields improved seeds	0.79
The risk from drought is less with improved seeds	0.78
The risk of losses due to frost is less with improved seeds	0.21
Cronbach' Alpha: 0.795, KMO: 0.767, Bartrlet Test: 613.85 (0.000), explained variance: 56%, rotation method: Varimax	

Both factors were used to segment farmers according to their attitudes towards improved seeds and risk perception. In both cases, results show the presence of three clearly differentiated clusters: (1) in transition—neutral attitude toward the improved seeds (n=105), (2) conservative—negative attitude towards the improved seeds (n=37), and (3) innovative—positive attitude towards the improved seeds (n=58). Regarding the attitudes towards risk, the segments were: risk averse, risk neutral, and risk loving. Using the AHP methodology, we also identified the main objectives that farmers took as a reference to guide its operation. Notably, the economic objectives were the most important (63.50%, 51.16%, and 48.46% for farmers in transition, conservative, and innovative categories, respectively), followed by environmental (22.32%, 27.75%, 38.88%) and socio-cultural objectives (14.18%, 21.09%, 12.67%). Importantly, farmers in transition have an increased interest in the economic objectives, while the conservatives have an increased interest in the socio-cultural and the innovators in the environmental objectives.

Table 15 shows the descriptive statistics of the main variables that influence the time of adoption of improved seed corn by farmers. The table shows that of the 200 farmers, 20% are censored (non-adopters) and the rest (80%) are adopters of improved seeds at the time of conducting the survey. Farmers who adopted have an average age of 51 years old, have three family members, and a higher education. They are farmers who learned about improved seeds through a technician and have attended courses on technology; they also have about five hectares of land cultivated with a yield of 4 tha^{-1}. Comparatively, censored farmers are older (75 years old), with six members in the family and education being low (illiterate, basic education, secondary education). Additionally, these farmers obtained information on the improved seeds from other farmers; they also did not attended courses on technology. These are farmers with an area of two hectares of arable land, and their yield is 2 tha^{-1}.

Table 15. Description of the variables used in the survival model statistical analysis (n=200)

Covariates	Variable description	Censored (n= 39)		Adopters (n= 161)		Total (n=200)	
		Mean	Std.	Mean	Std.	Mean	Std.
Dependent variable							
Duration	Number of years from farmer is responsible for planting corn until his adopt						
Explanatory variables							
Household head age	Age of the farmer in years	75	9	51	11	56	15
Reform NAFTA	Dummy variable to measure the effects of NAFTA introduced in 1994 (0: Before NAFTA, 1: after NAFTA)	1	0	1	0	1	0
Education	Education of farmers (0: illiterate, basic education, secondary education; 1: higher education)	0	0	1	0	1	0
Information	The way by which was known technology (1: technology met by a technician, 0: by a farmer)	0	0	1	0	1	0
Members	Number of members in the household (Continued)	6	1	3	1	4	2
Family workers	Number of family workers (man –equiv.)	2	1	1	1	1	1
Family member with university education	Number of family member with university education (0: No, 1: Yes)	0	0	1	0	1	0
Generations in agriculture	Number of generations in agriculture (Continued)	4	2	3	1	4	1
Generations in planting corn	Number of generations in planting corn (Continued)	4	2	3	1	3	1
Another crop	Having other crops (0: No, 1: Yes)	0	0	0	0	0	0
Aid received	Aid received by the government (0: No, 1: Yes)	0	0	1	0	1	0
Potential acceptance of improved corn seeds (segmentation results)	Attitudes towards improved corn seeds 1: Neutral attitude the improved seeds, 2: negative attitude towards the improved seeds, 3: positive attitude towards the improved seeds)	2	1	2	1	2	1
Risk attitude (segmentation results)	risk averse (1: risk averse, 2: cautious about risk, 3: risk loving)	2	1	2	1	2	1
Courses	Technology courses taken (0: No, 1: Yes)	0	0	1	0.1	1	0
Hectares	Number of hectares planted with corn (Continued)	2	1	5	3	5	3
Yield	Tonnes per ha	2	0	4	1	4	1
Sales	Sales of corn in Mexican pesos (Continued)	2,646	1,331	21,948	23,857	18,235	22,732
Economic objective	Relative importance of the economic objectives	1	0	1	0	1	0
Socio-cultural objective	Relative importance of the socio-cultural objectives	0	0	0	0	0	0
Environmental objective	Relative importance of the environmental objectives	0	0	0	0	0	0

4.3.2. Econometric analysis

The non-parametric analysis of the adoption periods considers the nature of censored data, and it is carried out through an estimated survival function according to Kaplan-Meier (KM). This information allowed us to suggest appropriate functional forms for parametric analysis in case they need to be performed (Kiefer, 1988). In addition, it helps represent the speed of adoption of the improved seeds in different farmer groups. The KM method was used in our case study to summarize the length of time before farmers adopted improved maize seeds. Figure 13 is used to describe the adoption-spell, which is the difference between the first year when the farmer is responsible for planting corn and the first year of improved seed adoption of corn. The horizontal axis shows the number of years that elapsed since the first year as responsible for planting corn until the first adoption of improved, and the vertical axis shows the respective probabilities.

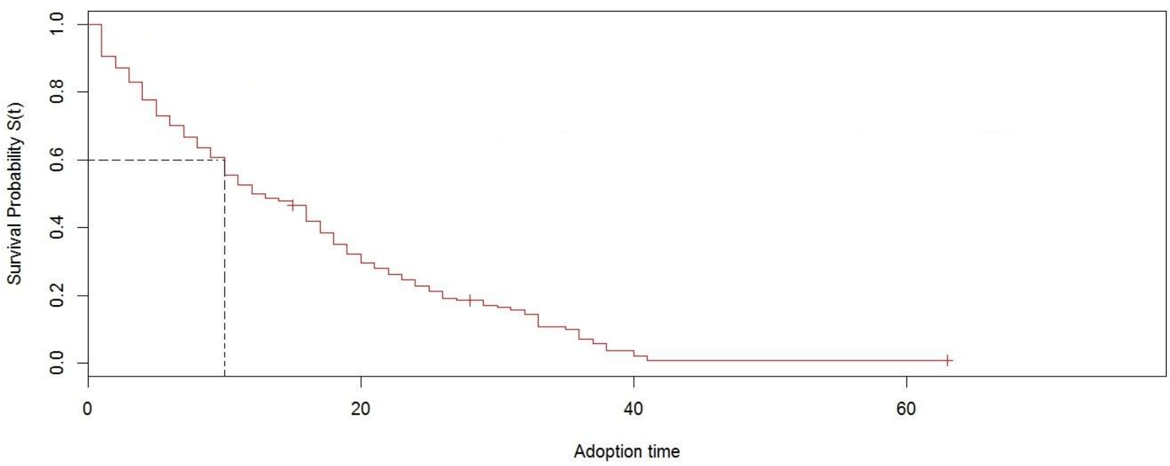

Figure 13. Kaplan-Meier survival estimate

The curve shows that the decision of the 60% of farmers who adopted was over a period of 10 years. Approximately 80% of farmers changed to improved seed in the first 25 years as showed in Figure 13.

The above statements are confirmed by the function of cumulative risk (Figure 14), showing that there is a slow adoption in the early years. Mexican farmers show a moderate trend over time for change, which is due to an attitude of distrust of different agricultural practices from those traditionally held. The farmer does not immediately adopt the improved seeds, but they prefer to wait for someone else to do it first. Based on this experience, potential users decide whether or not to use it, as also mentioned by Rivera and Romero (2003). The results contrast with those provided by Bekele and Abebe (2014) in Ethiopia, where 50% of farmers adopted hybrid maize during the two first years after the first exposure and then the rate of adoption dropped. Furthermore, in the case of the adoption of new wheat varieties in Pakistan, farmers adopted within the first six years (Nazli and Smale 2016).

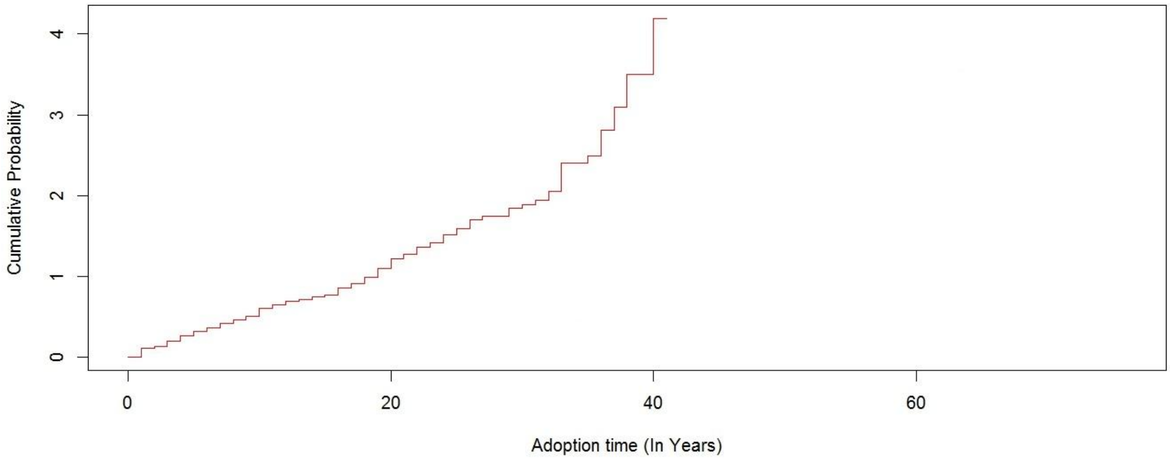

Figure 14. Cumulative adoption

The quality of the information that farmers has about agricultural technologies may affect their decision to adopt. Figure 15 relates the quality of information and the adoption rate of our sample. Results show that farmers who received information from a qualified institution or individual (agricultural technician) agreed to adopt improved seeds, while only 40% (28 of 68) receiving information from another source (employees, family, another farmer, media, consumers, and wholesalers) decided to change. Our results are in agreement with what Rogers (1995) noted about the quality and reliability of information in potential adopters increasing the likelihood of adopting.

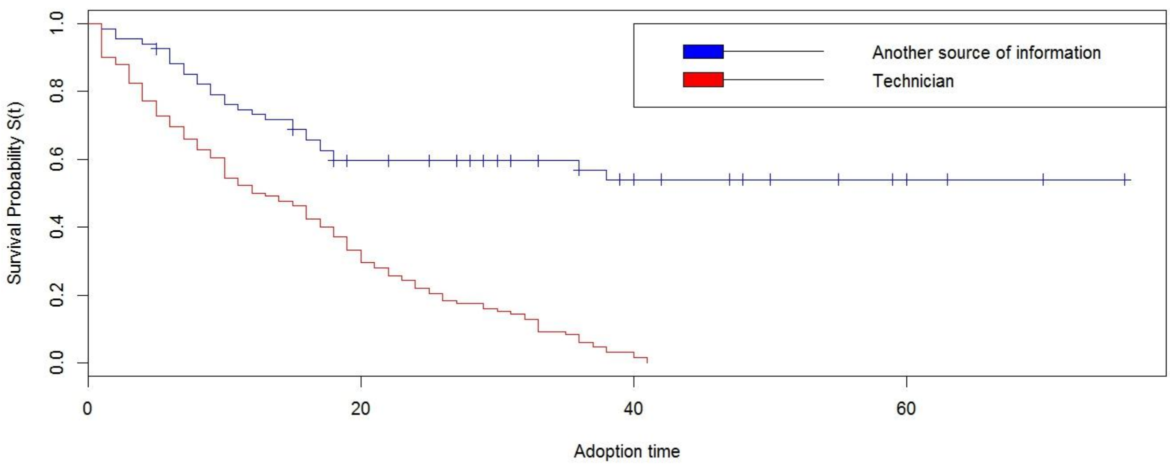

Figure 15. Kaplan-Meier survival curve by information received on the technology

Results of the KM estimator for the different regions analyzed are presented in Figure 16. Results show some level of heterogeneity among areas; for example, in the first twenty years, farmers in the region with the highest adoption rate were from Chiapas de Corzo, while the region of Villaflores exhibited the lowest adoption rate. These results are in agreement with the fact that Chiapas de Corzo is strategic, as it is located 15 km from the center of Tuxtla Gutierrez (the State capital) with better communication networks for the logistics of harvesting, marketing, and access to better information.

These results affirm the findings of Abdulai and Huffman (2005), whose studies found a negative and significant association between the distance of the market (big city) and the adoption of new agricultural technologies. In this context, previous studies have mentioned that the distance from the farm to the market may affect the adoption of agricultural technologies, especially in developing countries where communication networks are underdeveloped (Negatu & Parikh, 1999). Additionally, Rogers (1983) emphasized that those farmers living near the cities have higher adoption rates. Furthermore, they note that this behavior is attributed to reduced transport costs and to the higher possibility of easily contacting new extension workers and other farmers.

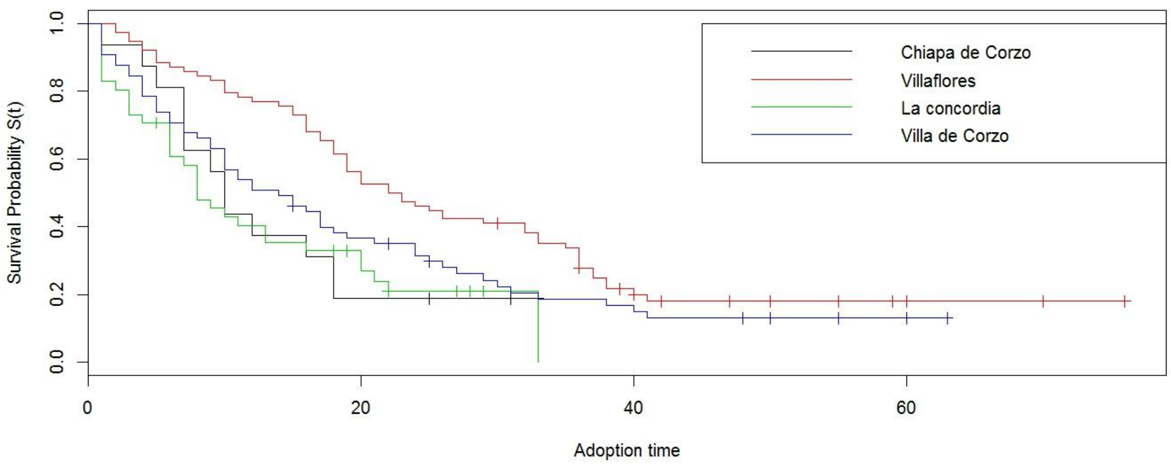

Figure 16. KM survival estimate by towns

Figure 17 explains Kaplan Meier estimator of the survival function disaggregated by attitudes. Results show some level of heterogeneity; for example farmers who have a positive attitude towards improved seeds tend to adopt more quickly. Results suggest also that farmers with positive attitudes and opinions toward improved seed corn have a shorter duration. Rigby et al. (2001) and Parra and Calatrava (2005) also found that positive attitudes positively influence the decision to adopt.

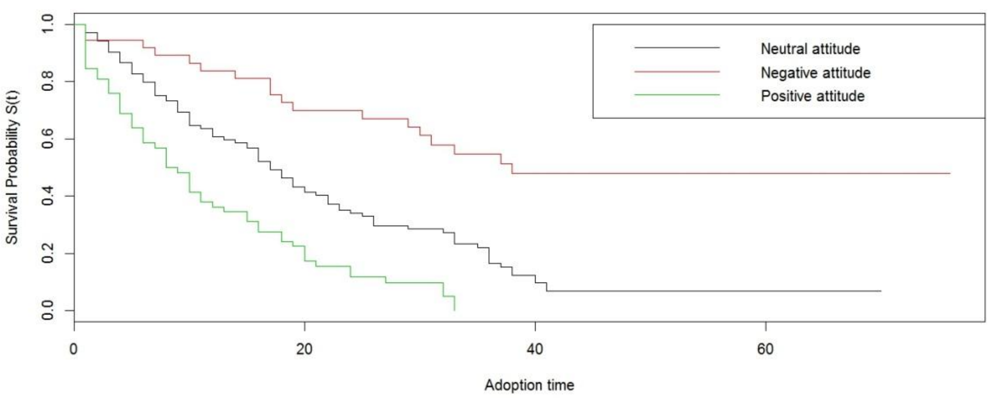

Figure 17. KM survival estimate by attitudes

Figure 18 shows that farmers who are more cautious about irrigation have faster adoption. Farmers' perception of risk and their attitude towards them play a decisive role in the decision-making process of peasant units for the adoption of technological innovations. The literature reports that the uncertainty generated in farmers is associated with the perceived risks in several areas. On the one hand, there is the availability of physical and financial resources that count; And on the other, the aspects of expected profitability with the use of the new technology. As well as, the risk and uncertainty of grain prices in the market; the personal characteristics of the farmer in terms of their partial or total disposition to change (Luna-Mena et al. 2016).

Regarding the availability of physical and financial resources, the total area reflecting household wealth is an indicator of farmers' ability to take greater risks and be willing to use improved maize seeds (Lunduka et al. 2012).

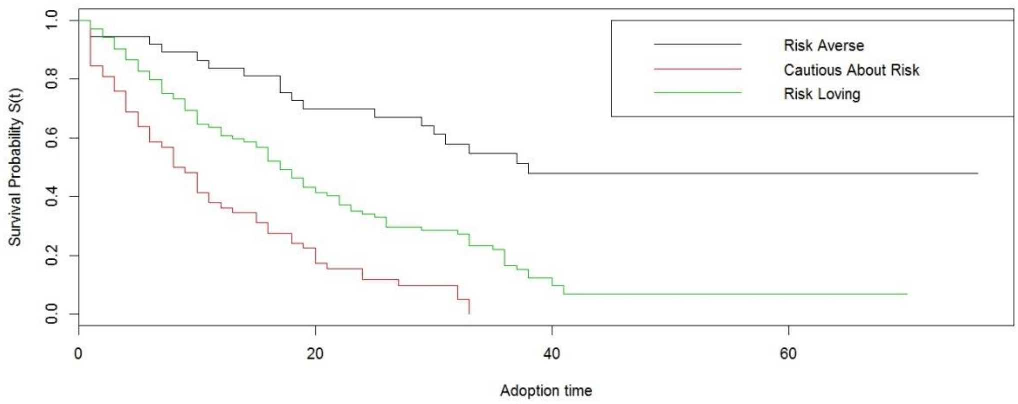

Figure 18. KM survival estimate by perceptions of risk

To estimate the risk and survival functions that consider the effect of different independent variables, we used the semi-parametric proportional risk model from Cox (1972) because it does not impose any restrictions on how the baseline risk function should be and also because it performed better with our data set. The model was estimated using the different covariates available in our questionnaire (see Table 15 for more details). We followed the forward method to determine the final list of variables included in the model. At a 95% confidence level, we rejected the null hypothesis that all coefficients are jointly equal to zero. Our estimated model (Table 16) explains 76.2% of the variation in survival times by the covariates.

Table 16. Results of the Cox proportional model for the adoption of improved seeds

Variables	β	$e^{(\beta)}$	*P value*
Household head age	-1.22	0.29	0.000***
Number of generations in agriculture	0.22	1.25	0.050**
NAFTA reform (year 1994)	-1.86	0.15	0.000***
Number of family workers	-0.37	0.68	0.000***
Number of received courses and extension contact for best farming practices	1.65	5.25	0.000***
PCA: Perception factor for accepting improved seeds	0.44	1.55	0.001**
PCA: Risk behavior (risk lover)	0.45	1.57	0.010*
Pseudo R^2	0.76		
Likelihood ratio test	286.8		
Wald	187.1		
Score (logrank) test	254.3		

Significance levels: *** p<0.001; **p<0.01, *p<0.05

Results indicate that seven covariates were better associated with the adoption rate of improved seeds among corn farmers in the area of study. As expected, young farmers tend to easily adopt the improved seeds; this is in line with the literature as Feder et al. (1985), Kafle (2010), and Ouma et al. (2014) found that older farmers tend to prefer their traditional agricultural practices. Furthermore, young people are associated with higher risk-taking behavior than the elderly, as shown by Simtowe et al. (2009). Our results also show that the increase in the number of generations working in agriculture increases the adoption of improved seed as well. In this context, farmers who have extensive experience from previous generations are able to better evaluate information about agricultural technology and better appreciate the advantages offered to them (Mignouna et al. 2011).

The dummy variable representing policy changes of the reforms undertaken by NAFTA in 1994 was also significant and negatively associated with the decision to adopt the improved seeds. That is, with the introduction of NAFTA in Mexico, the rate of adoption of improved seeds significantly decreases. This result is explained by the fact that the policy reform led to an increase in the price of the improved seeds, which negatively affected the production costs for both farmer groups, i.e., the farmers who already had cultivated the improved seeds and those likely to adopt. An increase in the production costs resulting from policy changes might negatively affect the adoption rate of technology (Yúnez & Barceinas, 2004). These findings coincide with Nadal and Wise (2004) who analyzed the NAFTA impact and mentioned that farmers continued planting their own seed. Moreover, Nadal (2000) highlighted that NAFTA affected the credit support and infrastructure of farmers, which sheds light on the low rate of adoption after the policy reform.

In the same way, our results showed that the improved seeds adoption was affected by the number of family members working in the corn production process. The higher the number of family members, the lower the adoption rate is. Farmers with the largest number of families involved in growing corn have fewer resources to invest since most of the resources are estimated to self-substance and maintenance obligations (Ouma et al. 2014). Due to budget constraints resulting from the high level of family expenditures (the number of the family members of creole farmers is higher), the farmers are restricted in the choices they make on which technology is employed, the degree of innovation, and their choice of crops (Feder et al. 1985). Our results show that the creole household farmers have six family members, in contrast to the adopter farmers (three family members). These results help in understanding that they are forced to select and save the best seed from a previous production season for their use in the following year; contrary to what happens with improved seed, which must be purchased each year to ensure expected returns. This previous result is in agreement with what Di Falco and Bulte (2011) found regarding the negative impact of family members on adoption rate. The authors mentioned that the number of families involved in production can negatively interact with the speed of technology adoption. Mafuru et al. (1999) also found that the probability of adoption of maize technology in Tazmania reduced by 1.9% for an increase in one unit of family labor. However, the literature also reflects some contrary results as in the case of Noltze et al. (2012) who indicated that large families provide the labor required for corn production practices, and this may increase the adoption rate of improvement.

Results showed that the number of courses farmers received and the extension contact on the best farming practices have a positive impact on the adoption rate. The continuous farmer contact with extension agents makes them aware of new technologies and how to applied them. Farmer perception towards innovation largely depends on their knowledge and information level and may increase their adoption rate. Farmers' knowledge on improved agricultural technology can be accelerated with the help of extension agents and farm information sources (Dibba et al. 2015; Kafle 2010). Likewise, other studies deem farmer objectives as relevant factors in explaining the decision to adopt (Kallas et al. 2009); however, in our case study, this variable was not statistically significant. When analyzing farmer perception towards the improved seeds using a confirmatory Principal Component Analysis (CPA), results show that the probability of adoption increases when perception is positive. Those who believe in the impact of the improved seeds in increasing their household income with better market acceptance of their products and higher productivity are more likely to adopt, i.e., have a higher hazard to convert. This finding is in agreement with what Parra and Calatrava (2005) found about positive attitudes positively influencing the decision to adopt. Becerril and Abdulai (2010) mentioned that the adoption of improved maize varieties helped increase the household per capita income by 136–173 Mexican pesos, as an average; thereby reducing their probability of falling below the poverty line by roughly 19–31%.

Regarding the farmers risk behavior variable, the results of the confirmatory PCA showed that farmers that exhibit risk-loving behavior are more likely to adopt technological innovations. These results are similar to those obtained by Brick and Visser (2015) who showed that farmers who are risk averse are less likely to use modern agricultural inputs. This result is also in agreement with Albert and Duffy (2012) who found that risk aversion increases with age and decreases with increasing cognitive ability (Dohmen et al. 2010). Figure 19 shows the conditional probability that farmers adopt improved maize seeds in different periods of time with respect to the possible values of the explanatory covariates included in our model (Table 16). Taking into account the estimated survival time by regressing proportional risk of Cox, the probability that a farmer will adopt before twenty years is 50%.

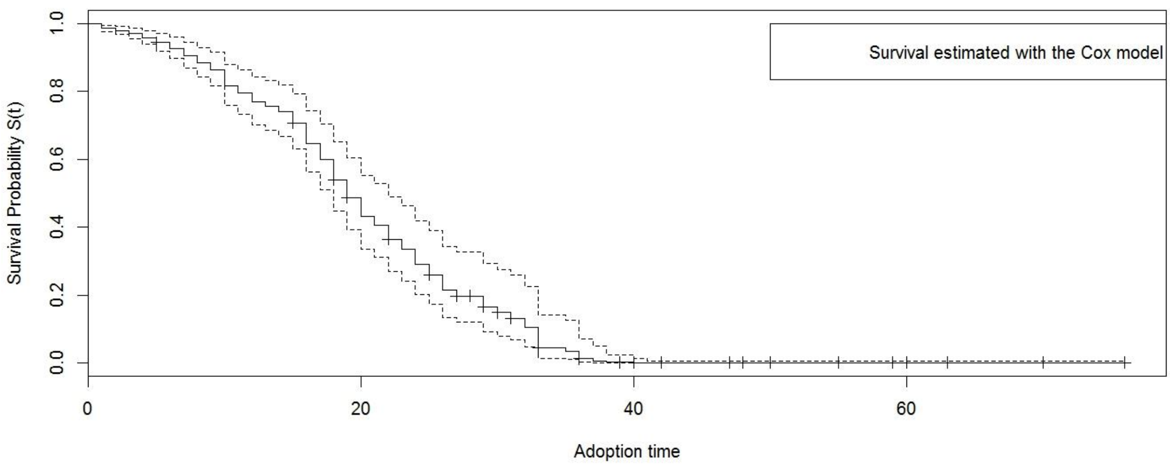

Figure 19. Cox model survival estimate

4.4 Conclusions

This study focuses on the evaluation of the determinant factors affecting the adoption rate of improved maize seeds, as well as the time of the conversion decision in Chiapas (Mexico), using the survival analysis model. The dependent variable represents the year in which the farmer is responsible for planting corn until the time of the adoption. The explanatory variables considered were: characteristics of the farmer and the farm, farm management, exogenous factors, and attitudes and risk behaviors. We used the Principal Component Analysis (PCA) to reduce the information regarding the perception and risk behavior. Our results show that the decision of the 60% of farmers who adopted was over a period of 10 years after they were responsible for the farm. Additionally, results show that this adoption rate also varied by location. Therefore, agricultural development strategies should address the different categories of farmers and locations to promote successful and improved seed maize adoption in the various locations.

These results provide the basis for better informed policy interventions in rural areas where an increase in the productivity of corn is required. Given the importance of the crop in the state of Chiapas, there is significant interest in understanding the determinant factors of adoption for improved seeds. Our study confirms that young farmers with low numbers of family members and high numbers of generations, who are also dedicated to agriculture, have sufficient information about innovation, and are willing to take risks, are more likely to adopt improved seeds. Results also reveal the incapacity of the agricultural reform of NAFTA in 1994 to ensure sustainable economic growth. This reform decreased the rate of adoption of improved seeds, which could be because the non-adopter farmers suffered from an increase in production costs. Furthermore, small producers of corn during the transition period of NAFTA reforms were exposed to high levels of market volatility and uncertainty. Accordingly, future trade agreements must be accompanied by policies that protect the most vulnerable strata of the population.

The importance of government support during the production process and market prices may play an important role in mitigating risk perception; this would also be a valid strategy in increasing the adoption rate of technologies. Agricultural reforms must have features that incorporate new programs for the transfer of financial resources, especially focused on small producers. In light of this, the agricultural development strategies should address the various categories of farmers and locations to successfully and efficiently promote the adoption of technological innovation. Additionally, extension efforts should be strengthened to increase the flow of information to farmers. Similarly, courses from qualified agents increase the likelihood changes toward adoption of improved maize seed. Policies promoting the adoption of improved seed maize should take into account the nature and factors that determine the adoption rate. The understanding of the dynamics the adoption may help improve strategies to accelerate adoption.

4.5 References

Abdulai, A., Huffman, E. (2005). The diffusion of new agricultural technologies: The case of crossbred-cow technology in Tanzania. *American Journal of Agricultural Economics,* 87(3): 645–659. doi:10.1111/j.1467-8276.2005.00753.x

Albert, S., Duffy, J. (2012). Differences in risk aversion between young and alder adults. *Neuroscience and Neuroeconomics,* 2(1): 3–9. doi:10.2147/NAN.S27184

Alcon, F., De Miguel, D., Burton, M. (2011). Duration analysis of adoption of drip irrigation technology in southeastern Spain. *Technological Forecasting and Social Change,* 78(6): 991–1001. doi:10.1016/j.techfore.2011.02.001

Alcon, F., García, M., De-Miguel, M., Fernandez, M. (2010). Adoption of soilless cropping systems in Mediterranean Greenhouses: An application of duration analysis. *Hortscience,* 45(2): 248–253.

Allison, P. D. (1982). “Discrete-time methods for the analysis of event histories”. In Bass Publishers. (Ed.), Sociological Methodology.Jossey- Leinhardt S. (pp. 61–98). San Francisco.

Asfaw, S., Shiferaw, B., Simtowe, F., Lipper, L. (2012). Impact of modern agricultural technologies on smallholder welfare: Evidence from Tanzania and Ethiopia. *Food Policy,* 37(3): 283–295. doi:10.1016/j.foodpol.2012.02.013

Asrat, S., Yesuf, M., Carlsson, F., Wale, E. (2010). Farmers' preferences for crop variety traits: Lessons for on-farm conservation and technology adoption. *Ecological Economics*, 69(12): 2394–2401.

Becerril, J., Abdulai, A. (2010). The Impact of improved maize varieties on poverty in Mexico: A propensity score-matching approach. *World Development*, 38(7): 1024–1035. doi:10.1016/j.worlddev.2009.11.017

Bekele, A., Abebe, Y. (2014). Analysis of adoption spell of hybrid maize in the Central Rift Valley, Oromyia National Regional State of Ethiopia: A duration model approach. *Journal of Agricultural Economics and Development*, 4(3): 207–213. doi:10.4314/star.v3i4.30

Bellon, M., Risopoulos, J. (2001). Small-Scale Farmers Expand the Benefits of Improved Maize Germplasm: A Case Study from Chiapas, Mexico. *World Development*, 29(5): 799–811.

Beyene, D., Kassie, M. (2015). Speed of adoption of improved maize varieties in Tanzania: An application of duration analysis. *Technological Forecasting and Social Change*, 96: 298–307. doi:10.1016/j.techfore.2015.04.007

Birol, E., Smale, M., Yorobe, J. (2012). Bi-modal preferences for bt maize in the Philippines: A latent class model. *AgBioForum*, 15(2): 175–190.

Bland, M., Altman, G. (1998). Survival probabilities (the Kaplan-Meier method). *BMJ*, 317(7172): 1572–1580.

Brick, K., Visser, M. (2015). Risk preferences, technology adoption and insurance uptake: A framed experiment. *Journal of Economic Behavior & Organization*, 118: 383–396. doi:10.1016/j.jebo.2015.02.010

Burton, M., Rigby, D., Young, T. (2003). Modelling the adoption of organic horticultural technology in the UK using duration analysis. *Australian Journal of Agricultural and Resource Economics*, 47(1): 29–54.

Camberos, M. (2000). La seguridad alimentaria de México en el año 2030. *CIENCIA Ergo-Sum*, 7(1): 49–55.

Cavallo, E., Ferrari, E., Bollani, L., Coccia, M. (2014). Attitudes and behaviour of adopters of technological innovations in agricultural tractors: A case study in Italian agricultural system. *Agricultural Systems*, 130: 44–54.

CIMMYT. (1993). La adopción de tecnologías: Guía para el diseño de encuestas. (C. P. de Economía., Ed.). México. 88p.

CONEVAL. (2016). Evolución de las líneas de bienestar y de la canasta alimentaria. http://www.coneval.org.mx/Medicion/MP/Paginas/Lineas-de-bienestar-y-canasta-basica.aspx. (Accessed July 2016). Retrieved July 1, 2016, from http://www.coneval.gob.mx/Informes/Coordinacion/INFORMES_Y_PUBLICACIONES_PDF/Construccion_lineas_bienestar.pdf

Cox, D. (1972). Regression models and life tables. *Journal of the Royal Statistical Society*, 34(2): 187–220.

D'Emden, F. H., Llewellyn, R. S., Burton, M. P. (2006). Adoption of conservation tillage in Australian cropping regions: An application of duration analysis.

Technological Forecasting and Social Change, 73(6): 630–647. doi:10.1016/j.techfore.2005.07.003

Dadi, L., Burton, M., Ozanne, A. (2004). Duration analysis of technological adoption in Ethiopian agriculture. *Journal of Agricultural Economics,* 55(3): 613–631.

De Cock, L. (2005). Determinants of organic farming conversion. In Paper presented at the XI International Congress of The European Association of Agricultural Economists, Copenhagen, Denmark (No. 24675). (p. European Association of Agricultural Economists).

De Souza, F., Young, T., Burton, P. (1999). Factors influencing the adoption of sustainable agricultural technologies. *Technological Forecasting and Social Change,* 60(2): 97–112. doi:10.1016/S0040-1625(98)00040-7

Dhakal, A., Cockfield, G., Maraseni, T. N. (2015). Deriving an index of adoption rate and assessing factors affecting adoption of an agroforestry-based farming system in Dhanusha District, Nepal. *Agroforestry Systems,* 89(4): 645–661. doi:10.1007/s10457-015-9802-1

Di Falco, S., Bulte, E. (2011). A dark side of social capital? kinship, consumption, and savings. *Journal of Development Studies,* 47(8): 1128–1151. doi:10.1080/00220388.2010.514328

Dibba, L., Zeller, M., Diagne, A., Nielsen, T. (2015). How accessibility to seeds affects the potential adoption of an improved rice variety: The case of the new rice for Africa (NERICA) in the Gambia. *Quarterly Journal of International Agriculture,* 54(1): 33–58.

Dohmen, T., Falk, A., Huffman, D., Sunde, U. (2010). Are risk aversion and impatience related to cognitive ability? *American Economic Review,* 100: 1238–1260. doi:10.1257/aer.100.3.1238

Feder, G., Just, R., Zilberman, D. (1985). Adoption of agricultural innovations in developing countries: A survey. *Economic Development and Cultural Chang*e, 33(2): 55–298.

Feder, G., Umali, D. (1993). The adoption of agricultural innovations. *Technological Forecasting and Social Change,* 43(3-4): 215–239. doi:10.1016/0040-1625(93)90053-A

Fox, J., Haight, L. (2010). La política agrícola mexicana: metas múltiples e intereses en conflicto. Subsidios para la desigualdad. Las políticas públicas del maíz en México a partir del libre comercio. (Dissa Impresores, Ed.).

Fuglie, O., Kascak, C. (2001). Adoption and diffusion of natural-resource- conserving agricultural technology. *Review of Agricultural Economics*, 23(2): 386–403.

Fujiie, H., Maruyama, A., Fujiie, M., Takagaki, M., Kikuchi, M. (2010). Determinants of NERICA adoption in Uganda based on duration analysis. *Tropical Agriculture and Development*, 54(1): 17–24. doi:10.11248/JSTA.54.17

Ghadim, A., Pannell, D., Burton, M. (2005). Risk, uncertainty, and learning in adoption of a crop innovation. *Agricultural Economics,* 33(1): 1–9. doi:10.1111/j.1574-0862.2005.00433.x

Ghimire, R., Huang, C., Shrestha, B. (2015). Factors affecting adoption of improved rice varieties among rural farm households in central Nepal. *Rice Science,* 22(1): 35–43.

Hair, J., Anderson, E., Tatham, R., Black, W. (1998). Multivariate data analysis . Uppersaddle River. Multivariate Data Analysis (5th ed) Upper Saddle River.

Hattam, E., Lacombe, J., Holloway, J. (2012). Organic certification, export market access and the impacts of policy: Bayesian estimation of avocado smallholder "times-to-organic certification" in Michoacán Mexico. *Agricultural Economics,* 43(4): 441–457. doi:10.1111/j.1574-0862.2012.00595.x

Hattam, C., Holloway, G. (2007). Bayes Estimates of Time to Organic Certification. In Paper pre- sented at the Agricultural Economics Society's 81st Annual Conference. UK: University of Reading.

Hellin, J., Bellon, M. (2007). Manejo de semillas y diversidad del maíz — AgriCultures Network. *LEISA Revista de Agroecología,* 23(2): 9–11.

Howley, P., Buckley, C., O Donoghue, C., Ryan, M. (2015). Explaining the economic "irrationality" of farmers' land use behaviour: The role of productivist attitudes and non-pecuniary benefits. *Ecological Economics,* 109: 186–193.

Islam, A., Barman, B., Murshed-e-Jahan, K. (2015). Adoption and impact of integrated rice-fish farming system in Bangladesh. *Aquaculture,* 447: 76–85. doi:10.1016/j.aquaculture.2015.01.006

Kafle, B. (2010). Determinants of adoption of improved maize varieties in developing countries: a review. *International Research Journal of Applied and Basic Sciences,* 1(1): 1–7.

Kallas, Z., Serra, T., Gil, J. (2009). Farmer's objectives as determinant factors of organic farming adoption. In Paper prepared for presentation at the 113th EAAE Seminar "A resilient European food industry and food chain in a challenging world", Chania, Crete, Greece, date as in: September (p. 19).

Kallas, Z., Serra, T., Gil, J. (2010). Farmers' objectives as determinants of organic farming adoption: the case of Catalonian vineyard production. *Agricultural Economics,* 41(5): 409–423.

Kamara, A., Kureh, I., Menkir, A., Kartung, P., Tarfa, B., Amaza, P. (2006). Participatory on-farm evaluation of the performance of drought-tolerant maize varieties in the Guinea savannas of Nigeria. *International Journal of Food, Agriculture and Environment,* 4(1): 192–196.

Kiefer, N. (1988). Economic duration data and hazard functions. J*ournal of Economic Literature,* 26(2): 646–679.

King, A. (2007). Diez años con el TLCAN. Revisión de la literatura y análisis de las respuestas de los agricultores de Sonora y Veracruz, México (No. 07-01). CIMMYT. México D.F.

Klein, P., Moeschberger, L. (2005). Survival analysis: techniques for censored and truncated data. Springer Science & Business Media. Second edition. 536 p.

Lancaster, K. (1978). Econometric methods for the duration of unemployment.

Econométrica, 47(4): 939–956.

Lancaster, K. (1992). The Econometric Analysis of Transition Data. Cambridge University Press, Cambridge. 349p.

Läpple, D. (2010). Adoption and abandonment of organic farming: An empirical investigation of the Irish Drystock Sector. *Journal of Agricultural Economics,* 61(3): 697–714. doi:10.1111/j.1477-9552.2010.00260.x

Lawless, F. (1982). Statistical models and methods for lifetime Data (Second edition.). Wiley, New York.

Li, J., Lammerts, E., Jiggins, J., Leeuwis, C. (2012). Farmers' adoption of maize (Zea mays L.) hybrids and the persistence of landraces in Southwest China: implications for policy and breeding. *Genetic Resources and Crop Evolution,* 59(6): 1147–1160.

López, M., Filipello, M. (1994). Maize seed industries revisited: Emerging roles of the public and private sectors. Primera parte de 1993-94 CIMMYT World Maize Facts and Trends: Maize Seed Industries Maize seed industries revisited: Emerging roles of the public and private sectors. Prime. Emerging Roles of the Public and Private Sectors. Mexico, D.F.

Luna, B., Hinojosa, M., Ayala, O., Castillo, F., Mejía, J. (2012). Perspectivas de desarrollo de la industria semillera de maíz en México. *Revista Fitotecnia Mexicana,* 35(1): 1–7.

Luna-Mena, B., Reyes, J., Santoyo-Cortés, V., Rendón-Medel, R. (2016). Factores e innovaciones para la adopción de semillas mejoradas de maíz en Oaxaca. *Revista Mexicana de Ciencias Agrícolas,* 15: 2995-3007.

Lunduka, R., Fisher, M., Snapp, S. (2012). Could farmer interest in a diversity of seed attributes explain adoption plateaus for modern maize varieties in Malawi?. *Food Policy,* 37:504-510.

Mafuru, J., Kileo, R., Verkuijl, H., Mwangi, W., Anandajaysekeram, P., Moshi, A. (1999). Adoption of maize production technologies in the lake zone of Tanzania. (CIMMYT, Ed.). México, D.F. 38p.

Matuschke, I., Qaim, M. (2008). Seed market privatisation and farmers' access to crop technologies: The case of hybrid pearl millet adoption in India. Journal of *Agricultural Economics*, 59(3): 498–515. doi:10.1111/j.1477-9552.2008.00159.x

Mignouna, D., Manyong, V., Rusike, J., Mutabazi, K., Senkondo, E. (2011). Determinants of adopting imazapyr-resistant maize technologies and its impact on household income in Western Kenya. *J. Agrobiotechnol. Manag. Econ.,* 14(3): 158–163.

Mwangi, H. W., Kihurani, A. W., Wesonga, J. M., Ariga, E. S., Kanampiu, F. (2015). Factors influencing adoption of cover crops for weed management in Machakos and Makueni counties of Kenya. *European Journal of Agronom,* 69: 1–9. doi:10.1016/j.eja.2015.05.001

Nadal, A. (2000). The environmental and social impacts of economic liberalization on corn production in Mexico. Estudio realizado por Oxfam GB y WWF International. 130p.

Nadal, A., Wise, T. (2004). Working group on development and environment in the Americas the environmental costs of agricultural trade liberalization: Mexico-U.S. Maize Trade Under NAFTA. Discussion Paper Number 4. Working Group on Development and Environment in the Americas.

Nandi, R., Gowdru, N., Bokelmann, W., Dias, G. (2015). Smallholder organic farmer’s attitudes, objectives and barriers towards production of organic fruits and vegetables in India: A multivariate analysis. *Emirates Journal of Food and Agriculture,* 27(5): 396.

Nazli, H., Smale, M. (2016). Dynamics of variety change on wheat farms in Pakistan: A duration analysis. *Food Policy,* 59: 24–33. doi:10.1016/j.foodpol.2015.12.009

Negatu, W., Parikh, A. (1999). The impact of perception and other factors on the adoption of agricultural technology in the Moret and Jiru Woreda (district) of Ethiopia. *Agricultural Economics,* 21(2): 205–216.

Noltze, M., Schwarze, S., Qaim, M. (2012). Understanding the adoption of system technologies in smallholder agriculture: The system of rice intensification (SRI) in Timor Leste. *Agricultural Systems*, 108:64–73. doi:10.1016/j.agsy.2012.01.003

Ouma, J., Bett, E., Mbataru, P. (2014). Drivers of adoption of Improved Maize varieties in Moist Transitional zone of Eastern Kenya. *Journal of Economics and Sustainable Development,* 5(25): 2222–1700.

Parra, C., Calatrava, R. (2005). Factors related to the adoption of organic farming in Spanish olive orchards. *Spanish Journal of Agricultural Research,* 3(1): 5–16.

Rivera, A., Romero, H. (2003). Evaluación del nivel de transferencia y adopción de tecnología en el cultivo de caña de azúcar en Córdoba, Veracruz, México. *Avances En La Investigación Agropecuaria,* 21(2): 20–40.

Rigby, D., Young, T., Burton, M. (2001) The development of and prospects for organic farming in the UK. *Food Policy* 26: 599-613.

Rodríguez-Hernández R. Donnet, L. 2015. Caracterización de la Demanda de Semillas Mejoradas de Maíz en Tres Agro-Ambientes de Producción de Temporal en México. Instituto Nacional de Investigaciones Forestales Agrícolas y Pecuarias. Campo Experimental Valles Centrales de Oaxaca. Santo Domingo Barrio Bajo, Etla, Oaxaca, México. Libro técnico No. 20, 190 p.

Rogers, E. (1983). Diffusion of Innovations. (F. Press, Ed.). New York.

Rogers, E. (1995). Diffusion of Innovations. (T. F. Press, Ed.) (4th Editio.). NY.

Salazar, J., Rivera, H., Arévalo, S., Guevara, A., Mald, G., Raascón, Q. (2015). Calidad del nixtamal y su relación con el ambiente de cultivo del maíz. *Fitotec. Mex,* 38(1): 67–73.

Schroeder, C., Onyango, K., Ranabhat, N., Jick, N., Parzies, H., Gemenet, D. (2013). Potentials of hybrid maize varieties for small-holder farmers in kenya: a review based on swot analysis. *African Journal of Food, Agriculture, Nutrition and Development,* 13(2).

SIAP. (2016). Avances de Siembras y Cosechas por Estado y Año Agrícola. Secretaría de Agricultura, Ganadería, Desarrollo Rural, Pesca y Alimentación. Accessed

March 2016. Accessed March 2016 in http://www.gob.mx/siap/

Sibiya, J., Tongoona, P., Derera, J., Makandaa, I. (2013). Farmers' desired traits and selection criteria for maize varieties and their implications for maize breeding: A case study from Kwazulu-Natal Province, South Africa. *Journal of Agriculture and Rural Development in the Tropics and Subtropics,* 114(1): 39–49.

Simtowe, F., Zeller, M., Diagne, A. (2009). The impact of credit constraints on the adoption of hybrid maize in Malawi. *Review of Agricultural and Environmental Studies,* 90(1): 5–22.

Smale, M., Richard, J., Howard, L. (1994). Land allocation in HYV adoption models: An investigation of alternative explanations. *Agricultural, American Journal of Economics,* 76(3): 535–546.

Turrent, A., Wise, T., Garvey, E. (2012). El municipio en Chiapas en la coyuntura zapatista: un actor inesperado. Mexican Rural Development Research Reports. No. 16. 32 p.

Valdivia, R., Caro, F., Ortiz, M., Betancourt, A., Ortega, A., Vidal, V., Espinosa, A. (2007). Desarrollo participativo de híbridos sintéticos de maíz y producción de semilla por agricultores. *Agricultura Técnica En México,* 33(2): 135–143.

Valdivia, R., Espinosa, A., Tadeo, M., Caro, F., Aguilar, J., Vidal, V., … López, G. (2015). "Cora 2012": híbrido intervarietal de maíz para Nayarit y regiones similares. *Revista Mexicana de Ciencias Agrícolas,* 6(2): 417–420.

Veisi, H., Liaghati, H., Alipour, A. (2016). Developing an ethics-based approach to indicators of sustainable agriculture using analytic hierarchy process (AHP). *Ecological Indicators,* 60: 644–654.

Weber, C., McCann, L. (2015). Adoption of nitrogen-efficient technologies by U.S. corn farmers. *Journal of Environmental Quality,* 44(2): 391–401. doi:10.2134/jeq2014.02.0089

Yúnez, A., Barceinas, F. (2004). The Agriculture of Mexico After Ten Years of Nafta Implementation. Documentos de Trabajo (Banco Central de Chile), ISSN-e 0717-4411, No. 277, 2004. Chile: Banco Central de Chile.

CHAPTER 5

CONCLUSIONS AND FUTURE WORK

5.1 Conclusions

The joint use of the Analytic Hierarchy Process, the Choice Experiment, and the survival analysis methodologies were appropriate tools to analyze the adoption of technological innovations. Our study demonstrated the existence of a real demand for improved maize seeds in the study area. Such an event has become evident through the estimation of the willingness to pay and farmers' preferences when selecting seeds. Results also confirmed that the agricultural policy should be locally adapted and consistent with the farms' needs in each region. Efficient and differentiated agricultural and rural policies may play an important role in wealth distribution, which can increase the level of economic development and social equality. Therefore, the seed producers should promote differentiated seed products that meet the specific demands of farmers with easy access and fair prices. Therefore, it is necessary to develop an adequate, public, and easily accessible catalog on improved seeds to inform and help farmers in their adoption decision. Thereby, the farmer can decide what fits best according to their objectives, production planning, and market conditions. It is also essential that farmers obtain objective information about the seeds' quality, agronomic behavior, and capacity to adaptation in unexpected weather conditions. Public institutions are fundamental for scientific and technological development. However, it is relevant to transform the linear model of transference of research institutions to the producer towards a scheme in which the research covers the demands in an integral form, including the agro-industrial and market approaches.

Reducing investment in agricultural research in Mexico will worsen the differences between rural and urban conditions. Agricultural research can potentially improve rural livelihoods by uniquely addressing farmers' problems and enabling the development of more efficient technologies.

However, the increase of the cultivated area with the improved seeds will not ensure the survival of the rural economies; therefore, it remains on debate. Mexico is the center of origin of corn and important world center of its biodiversity with 59 native breeds. The very diverse Mexican multicultural cuisine that is linked to the biodiversity of maize, because native maize is its specialized and irreplaceable raw material. Therefore, in-depth studies on the subject and a monitoring and research program to detect and respond to threats of conservation of maize diversity are of paramount importance. Germplasm banks are an essential tool for safeguarding the diversity and sustainability of agricultural research and production.

5.2 Contributions

The contributions of this research are as follows:

1) Our research provides technical, socioeconomic and typological information of maize farmers in the Chiapas state that serves to promote differentiated adoption strategies for this important crop in the state.

2) Our research contributes to the existing literature on analyzing farmer preference of seed selection in Mexico by providing specific information at the regional level and in marginal areas in order to promote a “social breeding” program for the improved seed sector that considers the needs of small farmers by increasing their likelihood to adopt. At a methodological level, this paper contributes to DCE studies by introducing the choice variable as a proportional specification in the modeling approach of the WTP-space model by modeling the percentage of the different corn seed preferred in a choice set.

3) The usefulness of the decomposition derived from the application of the AHP is to offer information about the relative importance of the attributes, thus allowing a better understanding of the preferences of the respondents.

4) It also contributed to the scarce literature on the application of the survival analysis in agricultural technologies, specifically in Mexico. In the same way, it is hoped to provide the bases that allow a better intervention of agricultural policies and guide the works of generation and transfer of technologies. A better understanding of the underlying dynamics can help improve strategies to accelerate adoption.

5.3 Limitations

Although this research represents the first approach to the comprehensive study of farmers' behavior towards improved maize seeds in Mexico, their field of study has been limited to a specific geographical area and their extrapolation must be done with caution. Also, it is important to increase the sample size to have a better approach to reality.

The study has been carried out in a marginal area and with specific conditions, so other populations dedicated to the cultivation of corn could have a different perception and attitude towards the improved seeds. Also, the information of new analyses could be used to make comparisons that would be useful in understanding the variation of the demand for maize attributes as well as the heterogeneity of social preferences.

The use of declared preferences is an unequivocal and widely used source of information, but sometimes it may be distant from reality, since budget constraints and environmental constraints are not present with the same intensity as in a real situation of choice. Hence, in the future it would be important to develop the improved seeds analysis through some technique of revealed preferences that would offer greater accessibility to the data such as the choice experiment with economic incentive, experimental auction, lotteries, etc. From the comparison between declared and revealed preferences, one could check if the measure which the farmers express actually coincides with what they buy.

5.4 Future research directions

Future research should consider a deeper assessment of risk attitudes and a detailed assessment of extensionism in Mexico. Further research is also needed to evaluate the impact of programs aimed at improving corn marketing in Mexico and of programs of improvement of maize in Mexico.

Methodologies that take into account budgetary constraints in real scenarios can help to give a better perspective. Analyzing other maize producing states will help to show a broader context for this line of research. Also, the information from new analyses could be used to make comparisons that would be useful in understanding the variation of the demand of attributes of maize.

The suitability of the attributes in this case study was evaluated and corroborated. However, using new attribute combinations on improved seeds is necessary in order to cover new scenarios. A joint analysis of agricultural policies in Mexico and the impact of support given to maize farmers can help to have a vision for the sector's challenges and opportunities.

The analysis of a deep-rooted and important crop in Mexico can present different results from those that would be obtained when analyzing other technological innovations where the presence of substitutes or complementary goods would be more perceptible. Therefore, evaluating technological innovations should be a constant effort to feedback research.

APPENDIXES

Appendix 1. Script of questionnaire to farmers with improved maize seeds.

Nombre: ______________________________
No. de encuesta: __________ **Bloque:**___
Fecha de realización: ____________________
Localidad: ______________________________
Municipio: ______________________________

Centro de Investigación en Economía y Desarrollo Agroalimentario (CREDA-UPC)

Buenos(as) días/tardes. El CIMMYT y el CREDA están efectuando un proyecto de investigación con el objetivo de conocer la adopción de las variedades mejoradas. Los datos que usted proporcione en ningún momento le perjudicarán. Gracias anticipadas por su colaboración.

I. AGRICULTOR

1. **Año de nacimiento**: ____

2. **Sexo:** ☐ Hombre ☐ Mujer

3. **Miembros en el hogar** ___ Miembros
   ___ ≤ 5 años ___ 6 - 18 años
   ___ 19 - 59 años ___ ≥ 60 años

4. **¿Cuál es su nivel de estudios?**
   ☐ Sin estudios
   ☐ Primarios finalizados
   ☐ Primarios no finalizados
   ☐ Secundarios finalizados
   ☐ Secundarios no finalizados
   ☐ Universitarios finalizados
   ☐ Universitarios no finalizados

5. **¿De dónde procede su formación agraria?**
   ☐ Experiencia práctica
   ☐ Formación universitaria agraria
   ☐ Formación profesional agraria
   ☐ Cursos, conferencias, talleres, etc.
   ☐ Otros:_______________

6. **¿Algún miembro de su familia ha realizado/realiza estudios universitarios?** ☐ Sí ☐ No

7. **¿En qué régimen realiza la gestión en la explotación?**
   ☐ Soy el titular
   ☐ Soy un familiar del titular no asalariado
   ☐ Soy un familiar del titular asalariado
   ☐ Soy un arrendatario o asociado
   ☐ Soy una persona asalariada
   ☐ Otro régimen: ____________

8. **¿Con Ud. cuantas generaciones en su familia se han dedicado a la agricultura? ________** Generaciones
   ¿ y a la siembra de maíz?________ Generaciones

9. **¿Desde qué año es el responsable de esta explotación?** Desde el año: ____

10. **¿Desde qué año se dedica a la siembra de maíz?** Desde el año: _______

11. **¿De sus ingresos totales familiares que porcentaje procede de la agricultura? ____**%
    la siembra de maíz? ___%

12. **A qué distancia se encuentra su explotación de su casa?**____ km

II. EXPLOTACIÓN

13. ¿La tierra que Usted cultiva, qué tipo de tenencia tiene?
- ☐ Ejidal
- ☐ Pequeña propiedad
- ☐ Rentada
- ☐ Al partido
- ☐ Comunal
- ☐ Otro (Especifique) ______________________

14. ¿Cuánta superficie tiene sembrada con maíz?____ ha

15. Distribución de la superficie de la explotación
Superficie total (incluyendo construcciones) _____ ha

Superficie Agraria utilizada(Incluye tierras de cultivos, pastos, forestales)_____ ha

Superficie en propiedad _____ ha

Superficie en arrendamiento _____ ha

Superficie a medias _____ ha

Número de parcelas _____

16. ¿En una escala de 0 a 10, como considera la calidad del suelo que dispone?
(0 es baja calidad, 10 es alta calidad) _____

17. ¿Cuántos análisis de suelos ha realizado en los últimos 5 años en su explotación? ___

18. ¿Tiene dificultades de disponibilidad del agua para su explotación?
☐ Sí ☐ No

19. ¿Qué sistemas de cultivo emplea?
Cultivos de riego ____ ha

Cultivos de temporal (**ir a 21**) ____ ha

20. ¿Qué tipo de riego utiliza?
- ☐ Riego por gravedad
- ☐ Riego por aspersión
- ☐ Riego goteo
- ☐ Otros sistemas de riego: ____________

21. ¿Cuál es el método de recolección de cosecha que emplea?
☐ Manual ☐ Mecánico

22. ¿Qué cantidad de su producción comercializa a través de cada canal de distribución?
- ☐ Consumo propio _____kg
- ☐ Venta directa en la explotación _____kg
- ☐ Mayoristas convencionales _____kg
- ☐ Molinos _____ kg
- ☐ Comaleras _____kg
- ☐ Tortillerias _____kg
- ☐ Mercados de agricultores _____kg
- ☐ Cooperativas _____kg
- ☐ Reparto a domicilio o en su casa _____kg

23. ¿Cuántos empleados trabajan en su explotación?

	Especialización	*Fijo*		*Eventual*			*Horas por jornada*
		Tiempo completo	Medio tiempo	Tiempo completo	Medio tiempo	meses	
Usted							
Cónyuge							
Hijo 1							
Hijo 2							
Hijo 3							
Asalariado 1							
Asalariado 2							
Asalariado 3							
Otros							

** 1= Especialistas agrónomos, 2=Contrato de maquinaría, 3=Peón

24. Capital de trabajo

Construcciones			m^2 *de Planta*	*Año de construcción*	*Costo ($)*
Bodega					
Otros:					
Maquinaria	***Nº***	***Año de compra***	***Precio de compra***	***Coste Alquiler***	***potencia***
Tractores					
Sembradoras					
Otros					

25. Variedades de maíz actuales

Maíz variedades	Ha	Rendimiento (t/ha)	Precio ($/t)	Consumo Kg	Venta Kg
Criolla 1:					
Criolla 2:					
Criolla 3:					
Semilla mejorada 1:					
Semilla mejorada 2:					
Semilla mejorada 3:					

III. DATOS ECONÓMICOS

26. Indique por favor sus gastos e ingresos

	Criollo		Semilla mejorada	
A.1 Ventas totales				
Maíz	Kg	$/Kg	Kg	$/Kg
A.2 Arrendamientos: $				
A.3 Apoyos:				
Apoyos por el gobierno: $				
Otra ayuda: $				
A.4 Otros ingresos:				

Actividad o labor	Cantidad	Precio unitario	Importe total
1.- PREPARACION DEL TERRENO			
Limpia de terrenos			
Barbecho			
Rastreo			
Otros			
2.- SIEMBRA O PLANTACION			
Adquisición de semilla o planta			
Siembra			
Otros			
3.- FERTILIZACION			
Adquisición de fertilizantes			
Aplicación de fertilizantes			
Otros			
4.- LABORES CULTURALES			
Escarda o cultivo			
Deshierbe manual			
Adquisicion de herbicidas			
Aplicacion de herbicidas			
Otros			
5.- RIEGO Y DRENAJE			
Costo de agua			
Riegos			
Otros			
6.- CONTROL DE PLAGAS Y ENF.			
Adq. De ins. y fung.			
Aplic. De ins. y fung.			
Otros			
7.- COSECHA			
Cosecha			
Acarreo			
Otros			
Total costos directos			

27. ¿Tiene algún préstamo pendiente de pagar?

☐ Sí ☐ No

Destino del crédito	Total del crédito en $
Para operar	
Para invertir	
Para comercializar	

28. ¿Cuál es la finalidad de las ayudas económicas que recibe?

- ☐ Para cubrir los gastos de cultivo
- ☐ Para invertir en la compra de maquinaria
- ☐ Para mejorar la infraestructura de la explotación
- ☐ Para cubrir otros gastos: _______________

IV. ACTITUDES Y OPINIONES

29. ¿Qué fuente de información suele emplear para el desarrollo de sus actividades agrarias? Mencione las 3 más importantes.

- ☐ Ninguna fuente de información
- ☐ Miembros de la familia
- ☐ Los empleados
- ☐ Técnicos de casas comerciales (abonos, fertilizantes, etc.)
- ☐ Técnico asesor particular
- ☐ Otros agricultores
- ☐ Cooperativa o sociedad agraria de transformación
- ☐ Agencia de extensionismo del gobierno (SAGARPA)
- ☐ Centros de investigación o enseñanza
- ☐ Profesionales libres
- ☐ Medios de comunicación (prensa, televisión, radio)
- ☐ Literatura especializada; libros, revistas agrarias, folletos
- ☐ Los consumidores
- ☐ Los mayoristas y/o los detallistas
- ☐ Otro: ____________________

30. ¿En los últimos 3 años, ¿aproximadamente a cuántos cursos, conferencias, etc., sobre temas agrarios, ha asistido? ____

31. ¿Ha contratado en el último año algún tipo de seguro agrícola para sus cultivos? ☐ Sí ☐ No

32. ¿Qué ´porcentaje de su superficie ha asegurado?___

33. ¿Qué tipo de cobertura tiene su seguro agrícola? _______

34. ¿Cuánto pago por el seguro agrícola? ___$/ha

35. Ordene por orden de importancia los 3 aspectos que lo limitan para que Ud. aplique nuevas tecnologías en su cultivo, que le permitan obtener mejores rendimientos
- ☐ Falta de recursos económicos
- ☐ Necesidad de asesoría técnica
- ☐ Falta de organización por parte del sistema producto

36. ¿Según su criterio cuál es el objetivo más importante a la hora de producir? En caso que tengan igual importancia marque "1" y en caso contrario indique únicamente el grado de superioridad relativa del objetivo más importante.

A. Objetivos Económicos

Maximizar las ventas									Maximizar los beneficios totales de la familia							
9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9

Maximizar las ventas									Maximizar los beneficios del cultivo de maíz							
9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9

Maximizar los beneficios totales de la familia									Maximizar los beneficios del cultivo de maíz							
9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9

B. Objetivos socioculturales

Generar empleo en la zona									Impedir el despoblamiento del medio rural							
9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9

Generar empleo en la zona									Conservar los valores socioculturales existentes							
9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9

Conservar los valores socioculturales existentes									Impedir el despoblamiento del medio rural							
9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9

C. Objetivos medioambientales

Favorecer prácticas agrarias que respetan el medioambiente									Mantener la fertilidad del suelo							
9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9

Favorecer prácticas agrarias que respetan el medioambiente									Mantener razas criollas de maíz							
9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9

Mantener la fertilidad del suelo									Mantener razas criollas de maíz							
9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9

D. Comparación de los tres tipos de objetivos

Objetivos Económicos									Objetivos socioculturales							
9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9

Objetivos Económicos									Objetivos medioambientales							
9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9

Objetivos socioculturales									Objetivos medioambientales							
9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9

V. OPINIÓN SOBRE LAS SEMILLAS MEJORADAS

37. De los aspectos siguientes que le voy a mencionar, compare las semillas mejoradas respecto a la criolla.

Semilla mejorada vrs. criolla	Mayor	Igual	Menor	%
Tiempo y esfuerzo (× ha)				
Costo de producción $/ha				
Ingresos Totales $/ha				
Mano de obra (× ha)				
Ayudas recibidas $/ha				
Rendimiento (Kg/ha)				
Variabilidad rendimiento				
Variabilidad de precio				

38. Por favor, indique el grado en que usted está de acuerdo o en desacuerdo con cada una de las siguientes afirmaciones sobre las semillas mejoradas

Afirmaciones	*(0- Totalmente desacuerdo 10- Totalmente de acuerdo)* *No lo sé = no contestes*
Los precios de venta del maíz mejorado permiten cubrir los mayores costos de producción	
La siembra con semillas mejoradas de maíz podría asegurar el futuro de la explotación	
La siembra con semillas mejoradas de maíz da una imagen positiva para la explotación	
La siembra con semillas mejoradas incrementan los ingresos en el hogar	
La siembra con semillas mejoradas de maíz son diferentes a las semillas transgénicas	
Las semillas mejoradas de maíz son mejor aceptadas en el mercado	
La relación masa – tortilla es mayor con las semillas mejoradas	

39. En una escala de 0 a 10 indique su percepción de las actitudes de los siguientes grupos hacia las semillas mejoradas. (0 indica una percepción negativa y 10 una percepción positiva).

Agricultores de su zona ____

Los consumidores ____

Los agentes comerciales ____

Las entidades de crédito ____

Los miembros de su familia ____

40. Por favor, indique el grado en que usted está de acuerdo o en desacuerdo con cada una de las siguientes afirmaciones sobre los riesgos de las semillas mejoradas

Afirmaciones	*(0- Totalmente desacuerdo 10- Totalmente de acuerdo)* *No lo sé = no contestes*
El riesgo procedente de las sequías es menor con las SM	
El riesgo procedente de la fluctuación de los rendimientos es menor con las SM	
El riesgo de pérdidas por heladas es menor con las SM	
Los riesgos procedentes de la proliferación de plagas y enfermedades son menores con las SM	
El riesgo procedente de la comercialización es menor con las SM	
Existe un menor riesgo para la concesión de créditos a los agricultores con SM	

VI. AGRICULTORES CON SM DE MAÍZ Y EN CONVERSIÓN

41. ¿Podría indicarnos en qué año tuvo noticia o conocimiento por primera vez de las semillas mejoradas? Año: _______

42. ¿De dónde obtiene las SM?
- ☐ Casas semilleras
- ☐ Instancias de gobierno
- ☐ Otros:____

¿En qué mes compra la semilla de maíz?__________

43. ¿Por qué utiliza semillas mejoradas?
- ☐ Porque es fácil de conseguir
- ☐ Por su sabor y/o consistencia
- ☐ Por costumbre
- ☐ Por rendimiento
- ☐ Porque tiene mejor aceptación en el mercado
- ☐ Porque tiene mejor precio
- ☐ Porque es más resistente al viento, enfermedades, plagas
- ☐ Porque son plantas más pequeñas
- ☐ Otro ____

44. ¿Ha aumentado el tamaño de su explotación desde que inició la actividad en la misma?

Antes de adoptar: ☐ Sí ☐ No ¿Cuánto?___

Después de adoptar ☐ Sí ☐ No ¿Cuánto?___

45. Indique la superficie y el año de la implementación

Primer conocimiento sobre las SM		Año
Año de la toma de decisión por convertirse		Año
La primera conversión	ha	Año
El Primer incremento	ha	Año
El segundo incremento	ha	Año
El tercer incremento	ha	Año
La superficie actual	ha	

46. Indique la superficie del maíz con SM

Superficie calificada con maíz mejorado	ha
Superficie calificada con maíz criollo	ha

47. ¿Si bajaran los precios del maíz dejaría de cultivarlo?

Si bajan un 5-10% ☐ Sí ☐ No

Si bajan un 10-20% ☐ Sí ☐ No

Si bajan más de 20% ☐ Sí ☐ No

48. ¿Qué cantidad y tipo de ayuda pública recibe o recibió para la conversión a maíz mejorado?

- ☐ Ninguna
- ☐ Ayudas para la agricultura ___$/año
- ☐ Ayudas para cubrir los costos de la transición ___$/año
- ☐ Créditos a bajos intereses ___$/año
- ☐ Ayudas para la contratación de seguros ___$/año
- ☐ Ayuda para compra de semilla ___$/año

49. ¿Si bajaran las ayudas a la agricultura dejaría de cultivar SM?

Si bajan un 10-25% ☐ Sí ☐ No

Si bajan un 25-50% ☐ Sí ☐ No

Si bajan más 50% ☐ Sí ☐ No

50. ¿Cómo cree que evolucionaría la superficie con semillas mejoradas de maíz en su explotación?

	Corto plazo	Largo plazo
Mantener la superficie cultivada		
Disminuir la superficie cultivada		
Aumentar la superficie cultivada		
Abandonar la actividad agraria		
No lo sé		

VII. VALOR AGREGADO

51. ¿Elabora algún producto con valor agregado de maíz para la venta?

- ☐ Si
- ☐ No

52. ¿Qué productos elabora, precio y lugar de venta?

Producto	Precio	Lugar de venta

EXPERIMENTO DE ELECCIÓN

A continuación se va a presentar una serie de tarjetas donde se muestran DOS productos de maíz. El experimento consiste en que usted debe imaginar que este día tiene que tomar un tipo de maíz para cultivar, para lo cual tendrá que elegir entre los distintos tipos que se muestran en cada una de las tarjetas. Cada tipo de producto, se puede referir, ya sea al maíz criollo o al maíz mejorado. Los tipos de maíz pueden variar en diferentes características. En cada tarjeta, usted tendrá que seleccionar el tipo de maíz que elegiría si tuviera que llevarse uno a casa.

En el conjunto de las tarjetas se van a mostrar distintas características: precio, rendimiento, altura de planta, longitud de la mazorca y resistencia a enfermedades.

De acuerdo a la selección realizada en las tarjetas marcar con una **"X"** la opción elegida. De igual manera, de su superficie total mencione que porcentaje estaría dispuesto a dedicar para la siembra de los diferentes tipos de maíz.

	Opción 1 Criollo	Opción 2 Semilla mejorada	Opción 3 Otro cultivo
Tarjeta A	________%	________%	________%
Tarjeta B	________%	________%	________%
Tarjeta C	________%	________%	________%
Tarjeta D	________%	________%	________%
Tarjeta E	________%	________%	________%

Tarjeta F	________%	________%	________%
Tarjeta G	________%	________%	________%
Tarjeta H	________%	________%	________%
Tarjeta I	________%	________%	________%

Muchas gracias por su colaboración!!

Appendix 2. Script of questionnaire to farmers with creole seed.

Nombre: ______________________________
No. de encuesta: __________ **Bloque:**___
Fecha de realización: ___________________
Localidad: ____________________________
Municipio: ____________________________

Centro de Investigación en Economía y Desarrollo Agroalimentario (CREDA-UPC)

Buenos(as) días/tardes. El CIMMYT y el CREDA están efectuando un proyecto de investigación con el objetivo de conocer la adopción de las variedades mejoradas. Los datos que usted proporcione en ningún momento le perjudicarán. Gracias anticipadas por su colaboración.

VII. AGRICULTOR

53. Año de nacimiento: ____

54. Sexo: ☐ Hombre ☐ Mujer

55. Miembros en el hogar ___ Miembros

___ ≤ 5 años ___ 6 - 18 años

___ 19 - 59 años ___ ≥ 60 años

56. ¿Cuál es su nivel de estudios?

☐ Sin estudios

☐ Primarios finalizados

☐ Primarios no finalizados

☐ Secundarios finalizados

☐ Secundarios no finalizados

☐ Universitarios finalizados

☐ Universitarios no finalizados

57. ¿De dónde procede su formación agraria?

☐ Experiencia práctica
☐ Formación universitaria agraria
☐ Formación profesional agraria
☐ Cursos, conferencias, talleres, etc.
☐ Otros:_______________

58. ¿Algún miembro de su familia ha realizado/realiza estudios universitarios? ☐ Sí ☐ No

59. ¿En qué régimen realiza la gestión en la explotación?

☐ Soy el titular
☐ Soy un familiar del titular no asalariado
☐ Soy un familiar del titular asalariado
☐ Soy un arrendatario o asociado
☐ Soy una persona asalariada
☐ Otro régimen: ____________

60. ¿Con Ud. cuantas generaciones en su familia se han dedicado a la agricultura? ________ Generaciones
¿ y a la siembra de maíz?_________ Generaciones

61. ¿Desde qué año es el responsable de esta explotación? Desde el año: ____

62. ¿Desde qué año se dedica a la siembra de maíz? Desde el año: _______

63. ¿De sus ingresos totales familiares que porcentaje procede de la agricultura? ____%
la siembra de maíz? ___%

64. A qué distancia se encuentra su explotación de su casa?____ km

VIII. EXPLOTACIÓN

65. ¿La tierra que Usted cultiva, qué tipo de tenencia tiene?

- ☐ Ejidal
- ☐ Pequeña propiedad
- ☐ Rentada
- ☐ Al partido
- ☐ Comunal
- ☐ Otro (Especifique) ______________________

66. ¿Cuánta superficie tiene sembrada con maíz?____ ha

67. Distribución de la superficie de la explotación

Superficie total (incluyendo construcciones) _____ ha

Superficie Agraria utilizada(Incluye tierras de cultivos, pastos, forestales)_____ ha

Superficie en propiedad _____ ha

Superficie en arrendamiento _____ ha

Superficie a medias _____ ha

Número de parcelas _____

68. ¿En una escala de 0 a 10, como considera la calidad del suelo que dispone?
(0 es baja calidad, 10 es alta calidad) _____

69. ¿Cuántos análisis de suelos ha realizado en los últimos 5 años en su explotación? ___

70. ¿Tiene dificultades de disponibilidad del agua para su explotación?

☐ Sí ☐ No

71. ¿Qué sistemas de cultivo emplea?

Cultivos de riego ____ ha

Cultivos de temporal (**<u>ir a 21</u>**) ____ ha

72. ¿Qué tipo de riego utiliza?

- ☐ Riego por gravedad
- ☐ Riego por aspersión
- ☐ Riego goteo
- ☐ Otros sistemas de riego: ____________

73. ¿Cuál es el método de recolección de cosecha que emplea?

☐ Manual ☐ Mecánico

74. ¿Qué cantidad de su producción comercializa a través de cada canal de distribución?

- ☐ Consumo propio _____kg
- ☐ Venta directa en la explotación _____kg
- ☐ Mayoristas convencionales _____kg
- ☐ Molinos _____ kg
- ☐ Comaleras _____kg
- ☐ Tortillerias _____kg
- ☐ Mercados de agricultores _____kg
- ☐ Cooperativas _____kg
- ☐ Reparto a domicilio o en su casa _____kg

75. ¿Cuántos empleados trabajan en su explotación?

	Especialización	*Fijo*		*Eventual*			*Horas por jornada*
		Tiempo completo	Medio tiempo	Tiempo completo	Medio tiempo	meses	
Usted							
Cónyuge							
Hijo 1							
Hijo 2							
Hijo 3							
Asalariado 1							
Asalariado 2							
Asalariado 3							
Otros							

** 1= Especialistas agrónomos, 2=Contrato de maquinaría, 3=Peón

76. Capital de trabajo

Construcciones			*m^2 de Planta*	*Año de construcción*	*Costo ($)*
Bodega					
Otros:					
Maquinaria	***Nº***	***Año de compra***	***Precio de compra***	***Coste Alquiler***	***potencia***
Tractores					
Sembradoras					
Otros					

77. Variedades de maíz actuales

Maíz variedades	Ha	Rendimiento (t/ha)	Precio ($/t)	Consumo Kg	Venta Kg
Criolla 1:					
Criolla 2:					
Criolla 3:					

IX. DATOS ECONÓMICOS

78. Indique por favor sus gastos e ingresos

	Criollo	
A.1 Ventas totales		
Maíz	Kg	$/Kg
A.2 Arrendamientos:	**$**	
A.3 Apoyos:		
Apoyos por el gobierno:	**$**	
Otra ayuda:	$	
A.4 Otros ingresos:		

Actividad o labor	Cantidad	Precio unitario	Importe total
1.- PREPARACION DEL TERRENO			
Limpia de terrenos			
Barbecho			
Rastreo			
Otros			
2.- SIEMBRA O PLANTACION			
Adquisición de semilla o planta			
Siembra			
Otros			
3.- FERTILIZACION			
Adquisición de fertilizantes			
Aplicación de fertilizantes			
Otros			
4.- LABORES CULTURALES			
Escarda o cultivo			
Deshierbe manual			
Adquisicion de herbicidas			
Aplicacion de herbicidas			
Otros			
5.- RIEGO Y DRENAJE			
Costo de agua			
Riegos			
Otros			
6.- CONTROL DE PLAGAS Y ENF.			
Adq. De ins. y fung.			
Aplic. De ins. y fung.			
Otros			
7.- COSECHA			
Cosecha			
Acarreo			
Otros			
Total costos directos			

79. ¿Tiene algún préstamo pendiente de pagar?

☐ Sí ☐ No

Destino del crédito	Total del crédito en $
Para operar	
Para invertir	
Para comercializar	

80. ¿Cuál es la finalidad de las ayudas económicas que recibe?

- ☐ Para cubrir los gastos de cultivo
- ☐ Para invertir en la compra de maquinaria
- ☐ Para mejorar la infraestructura de la explotación
- ☐ Para cubrir otros gastos: _______________

X. ACTITUDES Y OPINIONES

81. ¿Qué fuente de información suele emplear para el desarrollo de sus actividades agrarias? Mencione las 3 más importantes.

- ☐ Ninguna fuente de información
- ☐ Miembros de la familia
- ☐ Los empleados
- ☐ Técnicos de casas comerciales (abonos, fertilizantes, etc.)
- ☐ Técnico asesor particular
- ☐ Otros agricultores
- ☐ Cooperativa o sociedad agraria de transformación
- ☐ Agencia de extensionismo del gobierno (SAGARPA)

- ☐ Centros de investigación o enseñanza
- ☐ Profesionales libres
- ☐ Medios de comunicación (prensa, televisión, radio)
- ☐ Literatura especializada; libros, revistas agrarias, folletos
- ☐ Los consumidores
- ☐ Los mayoristas y/o los detallistas
- ☐ Otro: ______________________

82. ¿En los últimos 3 años, ¿aproximadamente a cuántos cursos, conferencias, etc., sobre temas agrarios, ha asistido? ____

83. ¿Ha contratado en el último año algún tipo de seguro agrícola para sus cultivos? ☐ Sí ☐ No

84. ¿Qué ´porcentaje de su superficie ha asegurado?___

85. ¿Qué tipo de cobertura tiene su seguro agrícola? _______

86. ¿Cuánto pago por el seguro agrícola? ___$/ha

87. Ordene por orden de importancia los 3 aspectos que lo limitan para que Ud. aplique nuevas tecnologías en su cultivo, que le permitan obtener mejores rendimientos
- ☐ Falta de recursos económicos
- ☐ Necesidad de asesoría técnica
- ☐ Falta de organización por parte del sistema producto

88. ¿Según su criterio cuál es el objetivo más importante a la hora de producir? En caso que tengan igual importancia marque "1" y en caso contrario indique únicamente el grado de superioridad relativa del objetivo más importante.

A. Objetivos Económicos

Maximizar las ventas									Maximizar los beneficios totales de la familia							
9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9

Maximizar las ventas									Maximizar los beneficios del cultivo de maíz							
9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9

Maximizar los beneficios totales de la familia									Maximizar los beneficios del cultivo de maíz							
9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9

B. Objetivos socioculturales

Generar empleo en la zona									Impedir el despoblamiento del medio rural							
9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9

Generar empleo en la zona									Conservar los valores socioculturales existentes							
9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9

Conservar los valores socioculturales existentes									Impedir el despoblamiento del medio rural							
9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9

C. Objetivos medioambientales

Favorecer prácticas agrarias que respetan el medioambiente									Mantener la fertilidad del suelo							
9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9

Favorecer prácticas agrarias que respetan el medioambiente									Mantener razas criollas de maíz							
9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9

Mantener la fertilidad del suelo									Mantener razas criollas de maíz							
9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9

D. Comparación de los tres tipos de objetivos

Objetivos Económicos									Objetivos socioculturales							
9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9

Objetivos Económicos									Objetivos medioambientales							
9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9

Objetivos socioculturales									Objetivos medioambientales							
9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9

XI. OPINIÓN SOBRE LAS SEMILLAS MEJORADAS

89. De los aspectos siguientes que le voy a mencionar, compare las semillas mejoradas respecto a la criolla.

Semilla mejorada vrs. criolla	Mayor	Igual	Menor	%
Tiempo y esfuerzo (× ha)				
Costo de producción $/ha				
Ingresos Totales $/ha				
Mano de obra (× ha)				
Ayudas recibidas $/ha				
Rendimiento (Kg/ha)				
Variabilidad rendimiento				
Variabilidad de precio				

90. Por favor, indique el grado en que usted está de acuerdo o en desacuerdo con cada una de las siguientes afirmaciones sobre las semillas mejoradas

Afirmaciones	*(0- Totalmente desacuerdo 10- Totalmente de acuerdo)* *No lo sé = no contestes*
Los precios de venta del maíz mejorado permiten cubrir los mayores costos de producción	
La siembra con semillas mejoradas de maíz podría asegurar el futuro de la explotación	
La siembra con semillas mejoradas de maíz da una imagen positiva para la explotación	
La siembra con semillas mejoradas incrementan los ingresos en el hogar	
La siembra con semillas mejoradas de maíz son diferentes a las semillas transgénicas	
Las semillas mejoradas de maíz son mejor aceptadas en el mercado	
La relación masa – tortilla es mayor con las semillas mejoradas	

91. En una escala de 0 a 10 indique su percepción de las actitudes de los siguientes grupos hacia las semillas mejoradas. (0 indica una percepción negativa y 10 una percepción positiva).

Agricultores de su zona ____

Los consumidores ____

Los agentes comerciales ____

Las entidades de crédito ____

Los miembros de su familia ____

92. Por favor, indique el grado en que usted está de acuerdo o en desacuerdo con cada una de las siguientes afirmaciones sobre los riesgos de las semillas mejoradas

Afirmaciones	*(0- Totalmente desacuerdo 10- Totalmente de acuerdo)* *No lo sé = no contestes*
El riesgo procedente de las sequías es menor con las SM	
El riesgo procedente de la fluctuación de los rendimientos es menor con las SM	
El riesgo de pérdidas por heladas es menor con las SM	
Los riesgos procedentes de la proliferación de plagas y enfermedades son menores con las SM	
El riesgo procedente de la comercialización es menor con las SM	
Existe un menor riesgo para la concesión de créditos a los agricultores con SM	

XII. AGRICULTORES CON SEMILLAS CRIOLLAS

93. ¿Por qué utiliza semillas criollas?
- ☐ Porque es más barato
- ☐ Porque es fácil de conseguir
- ☐ Por su sabor y/o consistencia
- ☐ Por costumbre
- ☐ Por rendimiento
- ☐ Porque tiene mejor aceptación en el mercado
- ☐ Porque tiene mejor precio
- ☐ Porque es más resistente al viento, enfermedades, plagas
- ☐ Otro ____

94. ¿De dónde obtiene el maíz criollo?
- ☐ De la cosecha anterior
- ☐ Instancias de gobierno
- ☐ Otros productores
- ☐ Otros:____________________________________

95. ¿Qué tipo de maíz criollo utiliza?
- ☐ Blanco
- ☐ Amarillo
- ☐ Azul
- ☐ Otras variedades:______________________________

96. Ha aumentado el tamaño de su explotación desde que inició la actividad en la misma? ☐ Sí ☐ No

97. ¿Ha tenido alguna vez en su explotación semillas mejoradas? ☐ Sí Cuántas ha: _______ ☐ No **(ir a 55)**

98. ¿Podría indicarnos en qué fecha se dio de alta y de baja? Alta ____ Baja ____

99. ¿Por qué ha abandonado la producción de semillas mejoradas en su explotación?
- ☐ Porque la agricultura con SM es muy arriesgada
- ☐ Porque no es rentable económicamente
- ☐ Porque la semillas es cara
- ☐ Porque no sé donde conseguir la SM
- ☐ Por la dificultad técnica del cultivo con SM
- ☐ Porque provoca pérdidas de cosechas
- ☐ Por encontrar dificultades comerciales
- ☐ Problemas en encontrar fuentes de información fiables
- ☐ Por dificultades en adquirir los factores de producción
- ☐ Por la falta de implicación de las entidades públicas
- ☐ Por las pocas ayudas del gobierno
- ☐ Por el sabor y/o consistencia
- ☐ Por mantener los razas criollas
- ☐ Otra________

100. ¿Tiene intención de usar SM en un futuro próximo?
☐ Seguro Si ☐ Probablemente Sí ☐ No lo sé
☐ Probablemente No ☐ Seguro No

101. ¿Qué porcentaje de aumento mínimo de los precios de venta necesitaría para utilizar las SM? _____%

102. Teniendo en cuenta que las ayudas a la agricultura en México están por debajo de la media, ¿qué porcentaje de aumento mínimo en las ayudas necesitaría para producir SM? ______ %

103. En una escala del 1 al 5 indique su grado de acuerdo o desacuerdo con las limitaciones y motivaciones para la conversión a las SM. (1 es Muy en desacuerdo y 5 absolutamente de acuerdo).

Limitaciones	**Muy en desacuerdo** 1	**En desacuerdo** 2	**Indiferente** 3	**De acuerdo** 4	**Absolutamente de acuerdo** 5
Los precios de las SM no son lo suficientemente altos para rentabilizar la actividad					
Existe incertidumbre sobre los futuros cambios sobre las ayudas públicas a la agricultura con SM					
Existen dificultades para obtener información sobre las SM					
Costo elevado de las SM					
Se debe invertir en más insumo (fertilizantes, insecticidas, etc.)					
Motivaciones	**Muy en desacuerdo** 1	**En desacuerdo** 2	**Indiferente** 3	**De acuerdo** 4	**Absolutamente de acuerdo** 5
Se pude obtener un mejor rendimiento por hectárea					
Existen perspectivas favorables para la demanda de maíz mejorado porque la calidad es mejor					
Para diversificar los canales de distribución					
Para buscar un satisfacción personal					
Existe mejor precio del maíz mejorado					
Se tienen menos problemas técnicos en el proceso productivo					

VIII. VALOR AGREGADO

104. ¿Elabora algún producto con valor agregado de maíz para la venta?

- ☐ Si
- ☐ No

105. ¿Qué productos elabora, precio y lugar de venta?

Producto	**Precio**	**Lugar de venta**

EXPERIMENTO DE ELECCIÓN

A continuación se va a presentar una serie de tarjetas donde se muestran DOS productos de maíz. El experimento consiste en que usted debe imaginar que este día tiene que tomar un tipo de maíz para cultivar, para lo cual tendrá que elegir entre los distintos tipos que se muestran en cada una de las tarjetas. Cada tipo de producto, se puede referir, ya sea al maíz criollo o al maíz mejorado. Los tipos de maíz pueden variar en diferentes características. En cada tarjeta, usted tendrá que seleccionar el tipo de maíz que elegiría si tuviera que llevarse uno a casa.

En el conjunto de las tarjetas se van a mostrar distintas características: precio, rendimiento, altura de planta, longitud de la mazorca y resistencia a enfermedades.

De acuerdo a la selección realizada en las tarjetas marcar con una **"X"** la opción elegida. De igual manera, de su superficie total mencione que porcentaje estaría dispuesto a dedicar para la siembra de los diferentes tipos de maíz.

	Opción 1 Criollo	Opción 2 Semilla mejorada	Opción 3 Otro cultivo
Tarjeta A	________%	________%	________%
Tarjeta B	________%	________%	________%
Tarjeta C	________%	________%	________%
Tarjeta D	________%	________%	________%
Tarjeta E	________%	________%	________%

Tarjeta F	__________%	__________%	__________%
Tarjeta G	__________%	__________%	__________%
Tarjeta H	__________%	__________%	__________%
Tarjeta I	__________%	__________%	__________%

Muchas gracias por su colaboración!!