Maize adoption and biodiversity conservation in Mexico

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Abstract
Improving both agricultural productivity and sustainable resources management are recognized major policy and research issues to address rural development in Mexico. To understand why farmers are doing what they are doing (regarding maize variety management) is crucial. There is need to understand what factors can motivate them to adopt new varieties or continue planting traditional varieties. Three econometric models are applied in order to understand farmer's maize seed management in southern Mexico.

1.- Introduction

Poverty reduction, technology transfer and preservation of biodiversity are among the issues high on the global agenda regarding sustainable development after approval of the Millennium Declaration by General Assembly of the United Nations (UN, 2000). This declaration resulted in formulation of eight Millennium Development Goals (MDG) to guide international policies. Poverty alleviation, technology transfer and preservation of biodiversity in developing countries are strongly linked to agricultural development at national, regional and local levels.

The empirical evidence indicates that, on one hand, there is a general consensus among economists that technology change contributes to poverty alleviation. Benefits from new agricultural technology have influenced the poor directly, by raising incomes of farm households, and indirectly by raising employment, wage rates of functionally landless laborers and by lowering the price of food staples (De Janvry and Sadoulet, 2002; Bellon *et al.*, 2006; Minten and Barrett, 2006; Mendola, 2007). Maize germplasm is one component of agricultural technology. Of all the inputs used in agriculture, none has the ability to affect productivity as much as seed. Seed is a living organism that carries the genetic properties of plants. These genetic properties place an upper limit to yield potential and influence the

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productivity of other inputs by determining the ability of plants to convert sunlight, water, air, soil, and other nutrients into biomass (Morris, 1998c).

In Mexico, after 40 years of different programs and efforts to transfer maize technology by public and private institutions, in 1997 only 22% of the total area were planted with modern varieties –hybrid and open pollinated varieties (OPV)- (Morris and López-Pereira, 1999c). Furthermore in year 2000 more than 28% of the rural households were considered extreme poor, who lives under poverty line US$53.13 (per-capita/month) (CTMP, 2002). Agricultural technology opens great opportunities of increasing food crop production and reduce the crop vulnerability in developing countries; in rural areas the maize production plays a key role in the small-scale farmer's livelihoods. But questions are raised regarding agricultural technological change contributing to poverty alleviation, as the potential impact in the MDG's. Probably poor farmers do not have access to the new technology or their land characteristics do not permit technology performance. Many questions are still unanswered among technology adoption and poverty alleviation.

On the other hand many scholars and scientists argued that the seed technological change contributes to the genetic erosion of seed biodiversity. Since 1970 there have been fears of loosing maize genetic diversity due to the introduction of modern maize varieties (Brush *et al.*, 1992; Brush, 1995). As experience in Mexico shows that during 1990s these concerns have increased after the signing of the North America Free Trade Agreement [NAFTA] in 1994, due to increased imports of maize seed and grains from the United States of America (Dyer and Yunez-Naude, 2003; Dyer, 2006). Furthermore in 2000 Quist and Chaplea have found the dissemination and introgression of maize transgenic into landraces, considered it as huge risk because Mexico has a spectrum of maize types and is also the centre of diversity and origin of this cereal (Quist and Chapela, 2001; Wolfenbarger and González-Espinosa, 2004). Brush and Chauvet (2004) pointed out that the phenomenon of poverty and migration might have an influence on the loss of diversity in maize because of abandonment of the crop or reduction in the cultivated area.

Regarding MDGs Mexico has two major objectives, seeking sustainable agricultural development: one is to reduce the rural poverty through technological change; the second is the conservation of maize biodiversity. This paper analyzes the small-scale farmers maize portfolio choice; this cereal plays a key role in the farmer livelihoods as well as genetic resources [social and private values (Smale *et al.*, 2001)].

The gap in the literature: many empirical works on technology adoption have been published (Feder *et al.*, 1985; Feder and Umali, 1993), after the Green and post-Green Revolution – 1960-1980 and 1990 till present– respectively (Gollin *et al.*, 2005). Earlier works on maize adoption have been based on dichotomies of adoption decisions: modern vs. traditional varieties (Gamba *et al.*, 2002; Doss, 2003; Hintze *et al.*, 2003). Other possible technologies that are in between the two extremes are often ignored, i.e., farmers who adopt and plant traditional varieties, or recycled modern varieties call them Creolized varieties (Bellon and Risopoulos, 2001; Perales *et al.*, 2003b; Bellon *et al.*, 2006). Ignoring these maize types and farmer's practices may provide a misleading impression of the true impacts of improved varieties on the welfare of rural households.

The main objective of this study is to examine the factors that influence farmer's decision to adopt maize Hybrid or OPV technologies, and then to analyze the non-adoption decision, because non-adopter farmers are maize biodiversity conservers *de-facto* [as the inverse of adoption (Van-Dusen, 2000)]. This analysis is carried out in Coast of Oaxaca and Frailesca of Chiapas regions in 2001.

This study employs a multinomial-logit model to analyze the maize-portfolio choice by small-scale farmers in Chiapas. A Probit model is used to study the maize-portfolio adoption of modern-germplasm, and a Poisson model to assess the maize biodiversity conservation in Oaxaca. The data used in the study contain detailed maize-seed information, and soil characteristics, as well as information on the socioeconomic characteristics of the households and farm.

The remainder is organized as follows. The next section briefly discusses maize technology in Mexico. The third section outlines the random utility model for maize portfolio choice employed in the analysis, while the fourth section presents the empirical specification, and the fifth section provides a description of the data and definition of the variables. The results from the analysis are then presented, while the final section presents the main findings of the study.

2.- Maize Technology in Mexico

Public research institutes, national and international private seed companies, and rural producer's associations compound the Mexican maize seed industry. In 1943 the Mexican government joined the Rockefeller Foundation in establishing the Office of Special Studies, which resulted in an immediate intensification of native germplasm collection and storage activities, as well as of plant breeding efforts (Aquino, 1998). Additionally, after World War II, a network of international research centers was established to provide agricultural innovations for developing countries (Sunding and Zilberman, 2001). In the early of 1960s was created a new institution: the International Maize and Wheat Improvement Center (*Centro Internacional de Mejoramiento de Maíz y Trigo* [CIMMYT]). CIMMYT holds the global mandate for maize germplasm improvement in developing countries (Morris, 1998b). According to Aquino (1998) the modern maize varieties have been available in Mexico from early 1950s.

The modern varieties like Hybrids and Opened Pollinated Varieties (OPV) are in response to increase demand for food, decreasing land area for farming, improved yield weight and reduce the crop vulnerability (Brush, 1995). The modern varieties are the products of scientific maize breeding programs, whether hybrid or OPV, are referred to as modern variety, reflecting the fact that their characteristics have systematically been altered in ways that bring economic benefits to those who cultivate them. Although use of the term "modern" is appropriate in this context, an unfortunate consequence of the convention is that the traditional varieties or Landraces grown by farmers often end up being considered "non-modern". This clearly is not correct, Landraces have been subject to numerous cycles of improvement at the hands of farmers, many of whom are skilled at identifying superior germplasm and expert at selecting individual plants that embody desired traits (Morris *et al.*, 1999b).

In this study the maize is classified in to four types: 1) Maize Hybrids are produced crossing some combinations of genetically distinct parents. Conventional hybrids are produced using two or more "inbred" lines as parents, while non-conventional hybrid are produced from parents at least one of which is not inbred line. Inbred lines are typically developed through repeated cycles of controlled self-pollination in which the silks on a given plant are fertilizer-using pollen from the same plant (Pandey, 1998). 2) Maize Open Pollinated Variety (OPV) reflect the fact that their characteristics have systematically been altered in ways that bring economic benefits to those who grow them. 3) Maize Creolized is defined as originally improved variety –hybrid or OPV– that have been under farmer management (Bellon and Risopoulos, 2001). The creolization or hybridization is explained by Bellon and Risopoulos (2001); Bellon *et. al.* (2006); and Perales, Brush and Qualset (2003b) as process, where their empirical evidence show that many small-scale farmers have taken up improved varieties and planted them alongside their local varieties. By design and by accident, these farmers have promoted hybridization between improved varieties and local varieties. And 4) Maize Landraces are varieties or populations of crop plants, often highly variable in appearance, whose genetic structure is shaped by farmer's selection practices and natural process over generations of cultivation (Bellon and Brush, 1994; Smale *et al.*, 2001; Perales *et al.*, 2003a; Smale, 2006).

The maize Hybrids and OPVs are the product of centralized scientific programs and not a technology that farmers have developed, their main traits are high yielding performance. And Landraces are the raw materials for crop breeding and source of continuing advances in yielding, pest resistance, and quality improvement (Van Dusen and Taylor, 2005).

3.- Theoretical Framework

Economic models for analyzing crop choice and diversity are derived from the partial adoption literature and agricultural households models (Feder *et al.*, 1985; Feder and Umali, 1993). If the farmer's technology choices are the result of profit maximization behavior, then the varietal choice will depend on the determinants of profit (Feder and Umali, 1993; Wale Zegeye, 2004).

Given the focus of the study is to examine the factors that influence to choose maize portfolio, with specific spotlight of modern varieties (Hybrids and OPVs), and maize Landraces selection, and any combination between four maize types. The assumption is that farmers can choose among the four maize types.

Given the above assumption, it may be assumed that, in deciding whether to adopt specific maize portfolio, following the framework of Abdulai and Binder (2006), the producer weighs up the expected utility of wealth from adoption represented as $U_A^*(\pi)$ and the expected utility of wealth from non-adoption represented as $U_N^*(\pi)$, and adoption occurs if $U_A^*(\pi) > U_N^*(\pi)$; under the assumption that farmers are risk neutral and that net farm returns (π) represent wealth. The parameters of this decision are usually not observable, but can be represented by a latent variable $U(\pi)=1$ if $U_A^*(\pi) > U_N^*$ and $U(\pi)=0$, if $U_A^*(\pi) \le U_N^*(\pi)$. The Utility of adoption can be related to a set of explanatory variables, Z as follows:

$$U(\pi) = \phi' Z_i + \varepsilon_i \quad \textbf{(1)}$$

where ϕ is a vector of parameters and ε is an error term with mean zero and variance σ_{ε}^{2}. The error term includes measurement error and factors unobserved by the researcher but known to the farmer (Abdulai and Binder, 2006). Variables included are age, education, farm size, soil quality, and other socioeconomic and resources characteristics of farmer and, government policy variables, such as subsidy or extension programs, may also be included in the vector Z. Equation (1) and $U_i^*(\pi)$ may also be expressed as:

$$\Pr(U=1)=\Pr(U_A^*(\pi)>U_N^*(\pi))=\Pr(\varepsilon_i>-\phi' Z_i)=1-F(-\phi' Z_i) \quad (2)$$

where F is the cumulative distribution function for ε. Assumptions about the functional form of F result in different models.

4.- The Empirical Specification

The cross-section data used for the analysis were obtained by a well-structured and comprehensive questionnaire from 325 small-scale farmer's households from twelve villages situated in two of the poorest states of Mexico i.e., Oaxaca and Chiapas[1]. Both regions are socioeconomic contrasting, for this reason the econometric modeling is analyzed separately.

The farmers in the study area can select between 4 possible maize types (MT): MT = (1) Hybrid, (2) OPV, (3) Creolized, and (4) Landrace. For each MT the farmer makes a discrete choice. Under the assumption that each farmer recognizes between all of the MT differences, and selects a particular maize type to specific plot. Obviously, it depends on farmer's land endowment, soil characteristics and socioeconomic constrains.

Each farmer choose a personal maize portfolio (MP) with M possible combinations, selecting one MT or creating a combination from different MTs. Table 1 shows at least 16 possible combinations of maize types. For instance, if farmer select MP=4 that means that he or she is planting maize hybrid, creolized and landrace.

[1] The questionnaire was a component of a CIMMYT's project.

Table 1. Maize portfolio options

All maize-portfolio options (a)	Hybrid	OPV	Criolized	Landrace	*Frequency* (b)
1 Hybrid	Yes	-	-	-	?
2 Hybrid & Landrace	Yes	-	-	Yes	?
3 Hybrid & Creolized	Yes	-	Yes	-	?
4 Hybrid, Creolized & Landrace	Yes	-	Yes	Yes	?
5 Hybrid & OPV	Yes	Yes	-	-	?
6 Hybrid, OPV & Landrace	Yes	Yes	-	Yes	?
7 Hybrid, OPV & Creolized	Yes	Yes	Yes	-	?
8 All	Yes	Yes	Yes	Yes	?
9 Nothing	-	-	-	-	?
10 Landrace	-	-	-	Yes	?
11 Creolized	-	-	Yes	-	?
12 Creolized & Landrace	-	-	Yes	Yes	?
13 OPV	-	Yes	-	-	?
14 OPV & Landrace	-	Yes	-	Yes	?
15 OPV & Creolized	-	Yes	Yes	-	?
16 OPV, Creolized & Landrace	-	Yes	Yes	Yes	?

(a) M=16. (b) Number of Household-farm

This multi-crop or coexistence of different maize types is often observed in the farmer's field. Each farmer makes a particular crop portfolio; as he or she can maximize their utility by planting one maize type or given combination among varieties.

Each farmer can choose the MP from *M=16* possibilities portfolio options, where $U^*_{MP} = \max(u^*_1 \ldots u^*_M)$ assuming that the utility of alternative $i-th$ is greater than utility of alternative j, that is $U_{MP_i} > U_{MP_j}$, for all $i \neq j$ Unordered-choice models can be motivated by random utility model. For the $i-th$ farmer faced with j choices (Greene, 2003). Suppose that the utility of $i-th$ election is:

$$U^*_{MP_i} = \phi'_{MP_i} Z_{MP_i} + \varepsilon_{MP_i} \quad (3).$$

where Z_{MP_i} is a set of physical and socioeconomic characteristics of the farm (described above). ϕ_{MP_i} is the parameter vector. ε_{MP_i} is a residual capturing errors in perception and optimization by the farmer. The farmer's utility from choosing Maize-Portfolio is not observable but his choice of a portfolio is, if the farmer makes choice $i-th$ in particular, then we assume that U_{MP} is the maximum among the *M* utilities. Then *I* is a polychotomous index denoting the farmer's maize portfolio choice: $I_{MP} = MP$

if only if $U^*_{MP} = \max(u^*_1 \ldots u^*_M)$ for all $U_{MP_i} > U_{MP_j}$ also $i \neq j$

if the residuals ε_{MP} are independently distributed with the extreme value distribution, then the choice of MP can be represented by a Multinomial-logit model, following Wu and Babcock (2000).

$$P_{MP} \equiv \Pr(I_{MP} = MP) = \frac{\exp(Z'\phi_{MP})}{\sum_{i=1}^{M} \exp(Z'\phi_i)} \quad (4)$$

were $MP = 1, 2, \ldots, M$

5.- The Data and Variable Definitions

Each farmer was face to face interviewed asking about how many maize types he or she has planted. All the M combinations of "maize-portfolio" are shown in Table 2.

Table 2. All Maize-Portfolio options

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

The Maize-Portfolio selection (dependent variable) by farmer shows that both regions are quite different in terms of maize types. All the farmers, in both regions have access to modern maize varieties; additionally both regions have similar agro-ecological ecosystems (one condition was looking the "*Maize-Tuxpeño germplasm*" performance see more in (Bellon *et al.*, 2003)), both regions are lowlands ranging from 0 to 1,200 meters above the sea level. Furthermore, the government programs are the same for all the Country (federal policy). The differences among regions are regarding socioeconomic and cultural (Ethnicity) characteristics. In Oaxaca small number of MP combinations are available, after that the two regions will be analyzed separately, for each region a specific econometric model will be used according to their characteristics. Doss (2003) suggest that studies on agricultural adoption could be collapse in detailed information i.e., into a roomy variable such as whether farmers are using improved varieties, recycled varieties, or local varieties, capturing the seed choice complexity. Doss also recommended using Multinomial logit econometric model estimation, rather than a simple binary model. Following Doss this is possible to joint the polychotomous index I_{MP} from M=16 to M=3 i.e., the dependent variable will be Maize-Portfolio = (1) Non-Adoption, (2) Partial-Adoption and (3) Adoption.

For Chiapas region a *Multinomial-Logit* econometric model is suitable, where the dependent variable will be I=0, 1 and 2. 0=MP-Landrace (non-adoption); 1=MP-any combination among four maize types (partial-adoption); and 2=MP-modern varieties (adoption), if the farmer plant maize hybrid, OPV or both. For Oaxaca region a *Probit* model is appropriate to analyze the maize adoption, where dependent variable will be I=0 and 1. Where 0=MP-Landrace (non-adoption); and 1=MP (adoption) if farmers plant modern maize varieties.

Given the focus of the study, there is interest to know the factors that influence maize biodiversity conservation. For Oaxaca region a *Poisson* econometric model is appropriate to analyze the number of maize landraces planted by oaxacan small-scale farmers. Where dependent variable will be I=0,1,…N, i.e., count data.

The explanatory variables are divided into three groups[2]: household characteristics, plot characteristics and government policy characteristics. The first set of variables are those that describe the household from Chiapas and are presented in Table 3. The first variable, age, is included in order to look at whether younger farmers are the ones adopting modern varieties, where the average age for non-adopters is 52, while partial-adopters are 45, and adopters 50 years old. The education variable is expected to contribute positively to maize technology adoption, where partial adopters are slight more educated than the rest. The variable on family size is for the number of adults-equivalent living in the household. This variable represents the pool of family labor available to the household for planting modern varieties and other activities. The average household size for non-adopters is 5.8, while 5 persons family members per household habit in the other two groups. The number of maize uses (consumption, sale, fodder, fuel and green-corn) is slightly higher in partial-adopters than the others two groups. The total area planted with maize (corrected by plant density and

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[2] The independent variables are presented by region and econometric model.

kilograms of seed per hectare) is higher for partial-adopters than the others two groups of farmers, on average of about 5.8 ha. The number of plots also is higher for partial adopters than the rest of the groups of farmers, on average of 2.32 plots.

The plot characteristics are used to determine whether household level of adoption is caused by agro-ecological conditions, and to correspond to the constraints and characteristics of the household farm. Four variables are used to describe the characteristics of the farm plot and its soil quality. They include rain-fed area, area soil quality (area bad = soil yellow, white and sandy), flat area (number of hectares flat), and stony area (stony much = there is a considerable number of stones in the plot).

The final set of variables are those representing government aid and programs. The program "*Kilo por Kilo*" (which consist to interchange modern seed by government and small-scale farmers, i.e., the government gives to farmers modern maize varieties for landraces) and government extension programs are expected to influence maize technology adoption.

Table 3. Variable names, definitions and descriptive statistics for Multinomial Logit model

Variable	Variable Description	Sample Mean	Stand Dev.	Sample Mean	Stand Dev.	Sample Mean	Stand Dev.
Dependent variable							
MAIZCHOA	Maize Portfolio Choice (DV)°	DV=0		DV=1		DV=2	
Independent variables							
Socioeconomic characteristics							
AGE	Age of the household head (Years)	52.03	17.34	45.36	13.29	50.38	13.33
EDUGROUP	Education level of the household head	1.03	1.15	1.32	0.86	1.22	0.93
AEFS	Adult Equivalent Family Size	5.82	2.47	5.00	2.20	5.12	2.42
STAPLEC	Number of Staple Crops	1.38	1.70	0.80	1.18	0.67	0.82
CASHCROP	Number of Cash-Crops	0.25	1.02	0.26	0.90	0.05	0.21
NUMUSES	Number of purposes for which maize is used	1.94	0.35	2.02	0.12	1.94	0.24
REMITTAN	If the household received remittances	0.28	0.46	0.18	0.39	0.19	0.39
AREAMAIZ	Quantity of land allocated for maize (Ha)	4.36	3.15	5.81	3.97	4.59	4.02
NUMPLOTS	Number of plots	2.03	1.09	2.32	1.08	1.59	0.92
LANDHOLD	Land holding (dummy)	0.81	0.40	0.94	0.24	0.91	0.29
Plot characteristics							
RAINAREA	Rain-fed area (Hectares)	6.52	5.32	9.21	7.99	6.32	5.32
ABAD	Area Bad Quality (Hectares)	0.16	0.59	0.74	1.35	1.05	1.85
FLATARE	Flat Area (Hectareas)	1.58	2.25	2.66	2.93	1.85	2.45
ARESTON3	Area Stony Much (Hectareas)	0.83	2.20	1.72	4.61	0.47	1.34
Government program							
SEEDX	Goverment MV-Seed Exchange program	0.16	0.37	0.45	0.50	0.36	0.48
ACCEXTEN	If the farmer has access to extension program	0.22	0.42	0.44	0.50	0.31	0.47
		N = 32		N = 66		N = 64	

°DV=Dependent Variable: 0=Non-adoption; 1=Partial-adoption; & 2=Adoption

Source: Field survey data, 2001

The explanatory variables for Oaxaca have contrasting characteristics among adopters and non-adopters farmers; Table 4 indicates variables employed in the Probit-econometric model. The household head are on average of 51 years old for adopters, while non-adopters being 49.9 years old. If we compare the farm experience –the variable used here is the Mincer (1974) experience variable, which is defined as experience = [age - years of schooling of household head – 5], farmers with more experience adopt modern germplasm. Also, farmers with slightly more literacy adopt modern maize varieties. The share of male members represents the pool of family labor available to the household. The sign for share of male members is expected to be positive if modern maize varieties are intensive in family labor. Cash-crops are expected to be positive if farm household is linked to the market and influence maize technology adoption. Staple crops are expected to be negative if the household is not linked to the market.

Table 4. Variable names, definitions and descriptive statistics for PROBIT model

Variable	Variable Description	Sample Mean	Stand. Dev.	Sample Mean	Stand. Dev.
Dependent variable					
MAIZADOPT	Maize Adoption	DV = 1		DV = 0	
Independent variable					
Socioeconomic characteristics					
AGE	Age of the household head (Years)	51.12	13.43	49.95	14.07
EXPERIEN	Experience =age-years schooling Hh head-5	43.44	14.85	42.14	15.36
LITERACY	If the Hh's head can read and write	0.81	0.40	0.71	0.46
HSIZENEW	Family Size	5.52	2.36	5.83	2.64
SHAM1550	Share of Male >15 & <50 years residing in Hh's	17.06	15.29	11.73	13.85
SHAF1550	Share of Female >15 & <50 years residing in Hh's	16.52	14.14	22.51	13.77
CASHCROP	Number of Cash-Crops	0.75	1.23	0.22	0.80
STAPLEC	Number of Staple Crops	0.44	0.92	0.51	0.86
REMITTAN	If the household received remittances (dummy)	0.29	0.46	0.23	0.42
LIVESTOK	Livestock: Tropical Livestock Unit	9.62	15.53	8.64	17.65
DISTANCE	Distance to major urban center (Minutes)	85.48	27.01	68.65	32.84
FARMSIZE	Farm size (Hectares)	11.32	16.30	9.18	13.20
Plot characteristics					
SLOPAREA	Slope Area (Hectareas)	1.64	1.84	1.50	1.88
AGOOD	Area Good Quality (Hectares)	1.74	1.63	1.27	1.33
Government program					
SEEDX	Goverment MV-Seed Exchange program	0.35	0.48	0.22	0.41
EXTENS	If the farmer has access to extension program	0.15	0.36	0.08	0.27
		N = 52		N = 111	

°DV=Dependet Variable: 1=use improved germplasm; 0=Otherwise

Source: Field survey data, 2001

The plot characteristics are used to determine whether household level of adoption is caused by agro-ecological constraints. Slope area is expected to be positive if farm household not adopt modern varieties. Area soil quality good = lowland, black and red soils, are expected that influence maize technology adoption. The last group of variables, government policy, such as the previous section, is expected to contribute to agricultural technology adoption.

Most of the explanatory variables employed in the Poisson model, were the same as described above in the Probit-model. A small number of new variables are introduced. In the first set of variables include Nativity (ethnicity), which is expected to be negative if the household farm plant landraces, indigenous farmers are the ones conserving diversity because of traditional practices or taste preferences. The numbers of plots is likely to influence the number of landraces, because local maize are for specific ecological niches or micro-ecosystem. The number of uses as well as is expected to contribute to maintain landraces, if the household farm has more than one use, is probably that he or she has more than one landrace. In the set of plot characteristics variables, slope area is expected to be positive; most of the landraces are planted in marginal land and poor soils types. Finally, government policy variables now include subsidy, which is expected to be negative, because subsidy (*PROCAMPO*) objective is to contribute to the crop technological change.

Table 5. Variable names, definitions and descriptive statistics for the POISSON model

Variable Name	Variable Description	Sample Mean	Standard Deviation
Dependent variable			
LANDRACD	Number of Landraces	1.197	0.455
Independent variables			
Socioeconomic characteristics			
EXPERIEN	Experience =age-years schooling Hh head-5	42.552	15.167
NATIVE	Ethnicity: 1=Non-native; 0=Otherwise	0.509	0.502
HSIZENEW	Family Size	5.730	2.546
SHA1550	Share of members >15 & <50 years residing in Hh's	34.007	19.448
NUMUSES	Number of purposes for which maize is used	1.350	0.583
CASHCROP	Number of Cash-Crops	0.387	0.990
OFFFARMW	Off Farm work by household head	0.184	0.389
FARMSIZE	Farm size (Hectares)	9.860	14.249
NUMPLOTS	Number of plots	1.129	0.418
Plot characteristics			
SLOPAREA	Slope Area (Hectareas)	1.550	1.860
AGOOD	Area Good Quality (Hectares)	1.418	1.440
ARESTON3	Area Stony Much (Hectareas)	0.235	0.658
Government program			
SUBSIDY	Gov subsidy: *PROCAMPO* program (dummy)	0.736	0.442
EXTENS	Access to agricultural extension program (dummy)	0.104	0.307

°DV=Dependet Variable: number of miaze landraces

6.- Empirical Results

6.1 Chiapas

The first results correspond to Chiapas region. Where the marginal multinomial logit results for the relationship between household's maize-portfolio selection and explanatory factors are presented in Table 6. Most of the factors were significant at the 5% and 10% levels. The likelihood chi-square value of 85.66436 was significant at the 1% level (p-value = 0.00000). The pseudo R square was 0.25107 and a moderate prediction of 64.19753% for the household choice was achieved.

Table 6. Maximum Likelihood Estimates of marginal effects for Multinomial Logit For Chiapas Farmers's Adoption of Maize

Variable	Landraces			Landrace & Modern			Modern		
	Coefficient	T-Ratio	Sig	Coefficient	T-Ratio	Sig	Coefficient	T-Ratio	Sig
Constant	-0.0617	-0.213		-0.5987	-0.835		0.6603	1.045	
Socioeconomic characteristics									
AGE	0.0047	2.037	**	-0.0118	-2.712	***	0.0071	1.731	*
EDUGROUP	0.0353	1.061		-0.0996	-1.507		0.0642	1.024	
AEFS	0.0285	2.102	**	-0.0536	-2.171	**	0.0250	1.056	
STAPLEC	0.0505	1.852	*	-0.0690	-1.271		0.0186	0.338	
CASHCROP	-0.0037	-0.102		0.1867	1.878	*	-0.1830	-1.690	*
NUMUSES	-0.1572	-1.337		0.5822	1.893	*	-0.4250	-1.585	
REMITTAN	0.1557	2.246	**	-0.1003	-0.776		-0.0554	-0.450	
AREAMAIZ	-0.0147	-1.301		-0.0254	-1.283		0.0400	2.063	**
NUMPLOTS	0.0512	1.478		0.1679	2.414	**	-0.2191	-3.114	***
LANDHOLD	-0.1845	-2.119	**	-0.0129	-0.071		0.1974	1.149	
Plot characteristics									
RAINAREA	0.0028	0.529		0.0153	1.720	*	-0.0181	-1.900	*
ABAD	-0.0904	-2.417	**	-0.0049	-0.133		0.0953	2.573	**
FLATARE	-0.0068	-0.579		0.0449	2.030	**	-0.0381	-1.668	*
ARESTON3	-0.0028	-0.226		0.0410	1.702	*	-0.0382	-1.444	
Government program									
SEEDX	-0.1332	-1.837	*	0.1202	1.072		0.0130	0.116	
ACCEXTEN	-0.0327	-0.511		0.2167	2.006	**	-0.1840	-1.720	*
	N=32			N=66			N=64		

Chi-square: 85.66436; P-value 0.00000.

Pseudo R-squared: 0.25107; Predicted: 64.19753

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

N= Number of observations

The simple way to interpret the results is by using the factor change. For instance, if age increases by 1 unit, the expected likelihood of maize-portfolio landraces increases by 0.47% and 0.71% for MP modern varieties, where this last result is contrary to adoption theory. In this case, could be that there are two types of old farmers on one hand farmers with enough wealth resources available to buy modern varieties, on the other hand, old poor farmers, who have not resources to buy agricultural technology, and recycle every season landraces. In the case of partial-adopters, if age increase by 1 unit, the expected likelihood of maize diversification decreases by 1.18%.

In the case of family size (adult-equivalent) results, if the household increases in 1 unit or member, the expected likelihood of maize landrace increase by 2.85% The opposite result is for partial adoption o major diversification, where result decrease by 5.36% This could be a result of the composition of household members, if the majority of members are male it increases the pool of labor available.

Staple crops influence maize landraces cultivation, similar findings by van-Dusen (2000) and van-Dusen and Talyor (2005) were presented, where maize landraces are strongly linkage with minor varieties (bens and squash) in the "Milpa" inter-crop system. Here, if the farmer increases in 1 unit of Staple crops, the likelihood of landraces increases by 5.05%. For the farmers –partial adopters- who plant more than one maize type, is linked with Cash-Crops (like: coffee, citrus, hibiscus, peanuts, etc.), if the small-scale farmer increase in 1 unit of cash-crop is probably that increase maize-type by 18.67% This is probably due to economies of scale among crops. But, for farmer-adopters is not a incentive, if they increase in one unit of cash-crops, the likelihood of modern varieties decrease by 18.30%.

If the number of maize uses (consumption, sale, fodder, fuel and green-corn) by the household increase, the demand to plant more than one maize type increase by 58.22%. This result explains why partial adopters have more than one maize type.

Whether the household receive remittances, increase the probability to plant maize landraces. In the context of rural Mexico, mostly of the young household members prefer off-farm work, and immigration to the United States of America. If the household receives remittance is likely that their decision will be to invest the money in other assets (like radio, TV, clothes, food, etc.) rather than in agricultural activities.

The farm size result is according to adoption theory, if the farm size is large, this increases the probability to plant modern maize varieties, i.e., if the area increases by 1 unit, the probability increase by 4.0%. The number of plots positive influence maize type diversification, if the farmer has more than one plot allocated contributes to plant more than one maize type by 16.79%. The results are contrary for farmers, who adopt maize hybrid and OPV, if the number of plots increases, the probability of adoption decreases by 21.19%, probably due to high inputs and labor demand in each plot. Furthermore, if the rain area increases, the probability to plant different maize types increases by 1.53% for partial adopters, and decreases the probability of adopters by 1.81%. These results are according to adoption literature, where access to irrigation influences agricultural adoption. The unexpected sign result for the area of bad quality and adopters, according to Wale (2004): "Farmers sometimes plant the best plot they have to the local varieties and more infertile ones to the others. The most important reason for these farmers is that they do no have much confidence on the sustainable performance of improves". Analogous results are reported for flat area and adopters, i.e., if the flat area increases, reduce the probability to plant modern varieties. The expected sign result for partial adopters, i.e., if the flat area increases, then probability to plant more than one maize type is increased by 4.49%. Furthermore, if the area is stony (much stones into the plot) then probability to plant more than one maize type is increased by 4.1% for partial adopters.

For the last set of variables, government programs, the expected sign expected for non-adopter's result, i.e., they do-not receive enough improved seed from the program of "agricultural technology change". Access to extension program has the expected result for partial adopters, i.e., they receive advice. Unexpected sign result from small-scale adopters, probably, the sales-man of the private maize-seed companies was more effective than the government program.

6.2 Oaxaca Probit-model

The second set of results corresponds to Oaxaca region. Table 7 presents the Probit econometric parameters outcome. The estimation model is statistically significant at the 1 percent level o better, as measured by the likelihood ratio test. According to Table 7, an increase in age decreases the probability to plant modern maize varieties by 12.52%, according to adoption theory, older farmers are more reluctant to adopt agricultural technology. Furthermore, if the farmer experience increase by 1 year, the likelihood to adopt agricultural technology is also increased by 12.40%. As well as if literacy level increase, the likely to adopt modern varieties also increases accordingly.

The household's pooled labor available influences maize adoption positively. Obviously, the share of male household members increases the likelihood; the share of female household members decrease the probability of maize adoption, perhaps due for two reasons: one is that women prefer certain maize landraces traits for cooking special dishes like "gourmet", and second, a high share of female members in the household reduce the labor availability. This picture is common in the majority of rural areas in Mexico, where young male leaves their towns and olders, children and women remain in the villages.

With respect to the probability of having cash crops contribute significantly to maize technology adoption. The result indicates whether the household increases by one cash crop, the probability of maize adoption increases by 43.3%. Perhaps due to economic of scale of the crops, i.e., if the farmer has linkage with the market, he or she has more information about maize technology. An unexpected sign for distance result is found in the study, i.e., if the distance increases, the probability to adopt new maize varieties are increased by 1.0%. This result is contrary to adoption theory, and the majority of empirical studies in adoption paradigm. Regarding plot characteristics, if the slope area increases by 1 unit, the likelihood of adoption is decreased by 14.55%. The slope area reduces the probability of maize technology adoption; obviously in slope plots is more difficult to use machinery and inputs, etc.

Table 7. Maximum Likelihood Estimates Parameters for PROBIT model for Farmer's Maize Adoption in Oaxaca

Variable	Coefficient	T-Ratio	Sig
Constant	-0.9775	-0.929	
Socioeconomic characteristics			
AGE	-0.1252	-1.711	*
EXPERIEN	0.1240	1.811	*
LITERACY	1.1008	3.135	***
HSIZENEW	-0.0383	-0.715	
SHAM1550	0.0157	1.807	*
SHAF1550	-0.0203	-2.167	**
CASHCROP	0.4331	3.000	***
STAPLEC	-0.0880	-0.629	
REMITTAN	0.4005	1.409	
LIVESTOK	-0.0047	-0.445	
DISTANCE	0.0103	2.451	**
FARMSIZE	0.0141	1.268	
Plot characteristics			
SLOPAREA	-0.1455	-1.880	*
AGOOD	0.1390	1.484	
Government program			
SEEDX	-0.0971	-0.316	
EXTENS	-0.0489	-0.129	

Chi-square: 43.52486; p-value: 0.000232

R^2: McFadden 0.2132; Veal/Zim. 0.37904

Correct Predictions: 77.3006%

Number of observations = 163

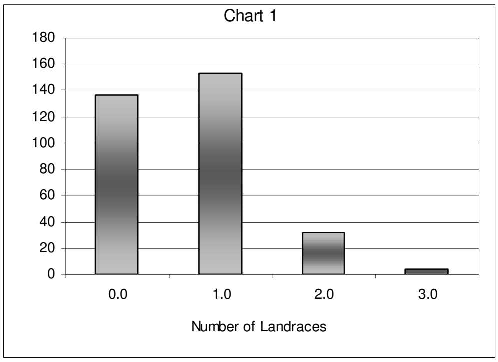
6.3 Oaxaca Poisson-model

Given the interest to study maize biodiversity conservation, a Poisson model is applied. One reason to employ the model is the low rate of maize adoption in Oaxaca and the high number of maize landraces. The results are presented in Table 8, the dependent variable is count data –number of maize landraces- from 0 to 3 as maximum observed. The dependent variable is censored on the left side, because cero correspond to adoption of modern varieties (Greene, 2003). Chart 1 present the form of Poisson distribution for the number of maize-landraces planted by farmers.

Table 8. Maximum Likelihood Estimates of Parameters for POISSON for Oaxaca Farmer's Maize conservation

Variable	Coefficient	T-Ratio Sig
Constant	-1.7898	-1.832*
Socioeconomic characteristics		
EXPERIEN	0.0019	0.170
NATIVE	-0.9980	-2.435**
HSIZENEW	-0.1696	-2.343**
SHA1550	0.0195	2.299**
NUMUSES	0.3860	2.058**
CASHCROP	-1.5952	-1.659*
OFFFARMW	0.7061	1.856*
FARMSIZE	-0.0272	-1.142
NUMPLOTS	0.9030	1.833*
Plot characteristics		
SLOPAREA	0.0028	0.011
AGOOD	-0.6019	-2.468**
ARESTON3	0.0801	0.299
Government program		
SUBSIDY	0.4480	1.059
EXTENS	1.1953	2.312**

Chi-square: 172.8181; p-value: 0.0000
Number of observations = 163



The analysis indicates whether the household head is "Mestizo" or non-indigenous reduce the likelihood to maintain maize landraces. The expected sign of the variable Native result, where indigenous people contribute to conserve maize biodiversity *in-situ* into the "Milpa" crop system (maize-bean-squash). The coefficient form family size is negative, this indicates if the household size increases then this reduce the probability to maintain landraces, this result depends on the share of the household members: if the members are between less than 14 years and more than 50 years old reduce the probability to keep maize landraces, because members in between 15 and 50 years contribute to maize biodiversity conservation.

The number of maize uses increases the probability of maize landraces conservation and the number of them as well; these results are quite similar to Wale-Zegeye (2004: 92) where his findings was that "a single variety does not satisfy multiple purposes to which farmers wish to place the variety". Also Bellon *et. al.* (2006) demonstrates that not only one maize type satisfies the household demand for dishes, fodder, sale, etc.

As well as the number of plots contribute to maintain local varieties. Farmer who have reported a higher number of plots, have reported higher number of local varieties, which supports the idea that many landraces have huge adaptability in different soils types and marginal land. Similar findings where found by (Bellon and Taylor, 1993; Van-Dusen, 2000; Van Dusen and Taylor, 2005), where the number of plots has a positive and significant influence on diversity conservation, consistent with a process of matching varieties to diverse soil or micro climatic conditions.

With respect to the probability of having cash crops reduce the likelihood of maize biodiversity conservation. The results are quit similar to van-Dusen (2000: 110) in *Sierra-Norte de Puebla*, where his findings: "an increase in the level of market integration decreases the level of diversity in a farmer's field". As inverse of maize modern varieties adoption, these results support the previous findings, where cash crops contribute the likelihood of maize adoption.

Finally, if the farmers have good soil quality (lowland, black and red soils) this is a disincentive to conserve maize biodiversity; these results are according to adoption theory. Unexpected sign for extension government program result. Probably, the advice is concern to conserve maize landraces.

Salient findings

Both regions are highly different in socioeconomic terms, as well as maize portfolio selection, but in agro-ecology conditions are quite similar, as well as topography. The study shows some small-scale farmer factors contributing to increase the maize productivity, as well as maize biodiversity conservation. Unfortunately these are divergent, i.e., young, educated and non-indigenous farmers adopt maize hybrid or OPV. On the other hand, old, illiteracy and indigenous farmers conserve maize biodiversity in poor soils and marginal land. The partial adoption contribute significantly in maize adoption and biodiversity conservation, this group of farmers reduce the *trade-off* between maize varieties. Creolized maize type plays a key role in their fields.

Remittances, surprising, contribute to maintain the rural agricultural production this result is opposite to van-Dusen (2005) findings in "Sierra-Norte de Puebla". But, the socioeconomic characteristics in van-Dusen study area are quite different than Oaxaca.

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