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RESEARCH ARTICLE

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Farmer preference for improved corn seeds in Chiapas, Mexico: A choice experiment approach

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Abstract

Appropriate technologies must be developed for adoption of improved seeds based on the farmers' preferences and needs. Our research identified the farmers' willingness to pay (WTP) as a key determinant for selecting the improved varieties of maize seeds and landraces in Chiapas, Mexico. This work also analyzed the farmers' observed heterogeneity on the basis of their socio-economic characteristics. Data were collected using a semi-structured questionnaire from 200 farmers. A proportional choice experiment approach 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 model in WTP-space approach was used. The results suggest that the improved seed varieties are preferred over the Creole alternatives, thereby ensuring higher yields, resistance to diseases, and larger ear size. For the preference heterogeneity analyses, a latent class model was applied. Three types of farmers were identified: innovators (60.5%), transition farmers (29.4%), and conservative farmers (10%). An understanding of farmers' preferences is useful in designing agricultural policies and creating pricing and marketing strategies for the dissemination of quality seeds.

Additional keywords: *Zea mays* L.; proportional choice experiment; WTP-space model; latent class model.

Abbreviations used: ASC (Alternative Specific Constant); BIC (Bayesian Information Indicator); DCE (Discrete Choice Experiment); GMNL (Generalized Multinomial Logit); INIFAP (Instituto Nacional de Investigaciones Forestales, Agrícolas y Pecuarias); LC (Latent class); PCE (Proportional Choice Experiment); WTP (Willingness To Pay).

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Introduction

In the early 1970s, Mexico experienced a strong increase in food production. However, soon after, the country gradually lost its self-sufficiency, leading to an increased dependence on imports of food and agriculture inputs (FAOSTAT, http://faostat.fao.org).

In 2015, corn (*Zea Mays* L.) production in Mexico was estimated at 24.9 million tonnes, with 2.95 t/ha and an increase of 77% in imports (SIAP, 2016). The low level of corn productivity in Mexico became a national food security issue because corn has been the main food product, especially in rural areas with extreme poverty and higher marginalization (CIMMYT, http://www.cimmyt.org/es/seguridad-alimentaria). The annual consumption of corn is estimated at 123 kg per capita, well above the worldwide average of 16.8 kg per capita (FAOSTAT).

The UN Food and Agriculture Organization (FAO) has estimated that corn production will not satisfy the global demand by 2050, as a result of climate change, shortage of production inputs, and emergence of new pests and diseases (Harrison, 2002). Consequently, the price of basic grains will increase significantly on the international market, making the import of corn into Mexico very costly (Nelson *et al.*, 2009). Therefore, improving corn productivity is indispensable to meet the future food demand.

The potential maize production in Mexico is 52 million tonnes, of which 28 million tonnes could be achieved in a short term. This increase can be reached without increasing the agricultural land use or without using transgenic maize. The use of improved technology, highly productive seed varieties, and modifying the farming practices would be sufficient (Turrent *et al.*, 2012). A further increase in productivity is hard to achieve as new farming technology and highly productive varieties have been already adopted by large-scale farmers. The main challenge hinges on small-scale farmers adopting innovative farming practices via more efficient use of the available resources and capital. Such agricultural technologies include the use of improved varieties, modern agricultural practices, and sustainable use of chemical fertilizers. According to Copeland & McDonald (2001), the use of improved varieties is the most effective means to increase crop yield and quality.

Over the years, the federal government of Mexico has promoted breeding programs through a variety of public and private institutions. However, there is a lack of coordination among the formal institutions engaged in research and development activities, as well as among these institutions, farmers, and private firms (Spielman *et al.*, 2011). As a result, the development of improved varieties is independent of the preferences of farmers, especially in marginal areas (Hellin *et al.*, 2006), leading to a lower rate of adoption (Luna *et al.*, 2011).

An ideal example is the state of Chiapas, which is mainly characterized by an agricultural system dominated by small farmers and low yields of 1.6 t/ha (SIAP, 2016). Furthermore, Chiapas has the largest demand of corn seed and the highest potential for production increase. However, it is still one of the states with the lowest implementation of improved seeds (30%), due to the farmers' lower perception of advantages in this technology (INEGI, 2015).

Bellon (1991) suggested that the preferences and priorities of farmers are highly heterogeneous. Therefore, many factors may affect farmers' choice of seeds, including final product attributes, socioeconomic variables, opinions and attitudes, risk perception, sociocultural environment, and access to information (Hellyer *et al.*, 2012).

Morris & Bellon (2004) noted that plant breeders often have weak links to the end users. Plant breeders receive rigorous instruction in the theory and practice of crop improvement and have little knowledge of survey methods to elicit structured feedback from farmers. As a result, what a conventional plant breeder considers important might not correspond with the preferences of the majority of farmers in an agricultural region. Consequently, the breeding program may represent a non-optimal combination of characteristics (Morris & Bellon, 2004). Accordingly, the best strategy to increase the adoption of improved seeds is considering the preferences of farmers, their production constraints, and what really influences their 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 (Herrera *et al.*, 2002; Birol *et al.*, 2006, 2009, 2012; Castillo & Chávez, 2013). 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 (Bellon & Risopoulos, 2001; Hellin *et al.*, 2006; Martínez *et al.*, 2006).

In this context, the objective of this research was twofold: (1) to identify key attributes and factors that determine the choice of maize seeds by local farmers, and (2) to estimate farmers' willingness to pay (WTP) for each descriptor and their heterogeneity on the basis of their socio-economic characteristics and heterogeneity.

Furthermore, among the methods available for preference analysis, the discrete choice experiment (DCE) is the most popular due to its validated economic theory. In this study, a variation of the DCE was used. The proportional choice experiment (PCE) approach was used to measure the WTP for a set of attributes that characterize maize seeds. We estimated the generalized multinomial logit (GMNL) in WTP space model. Furthermore, preference heterogeneity was assessed using the latent class (LC) modeling approach.

Our research provides specific information on farmers' preferences in seed selection in Mexico, which will help promote a "social breeding" program for small farmers. Second, this paper contributes to DCE studies by introducing the PCE as an alternative to the traditional approach by using the choice variable as a proportional in the modeling approach obtained by asking farmers the percentage of the different corn seed preferred in a choice set.

Methods

The choice experiment

The current literature provides several tools designed to analyze farmers' preferences for maize crop such as participative research (Bellon & Risopoulos, 2001; Ferro *et al.*, 2013), conjoint analysis (Makokha *et al.*, 2007; Hirpa *et al.*, 2012), and the use of descriptive analyses (Sibiya *et al.*, 2013).

In the early 1980s, the DCE was introduced as a technique for modeling consumer choices (Louviere, 2001). The DCE relies on the Lancaster's theory of value (Lancaster, 1966), which proposes that the utility of a product is decomposed into separable utilities for their characteristics. It is also based on the random utility theory (Thurstone, 1927), which proposes that subjects choose among alternatives according to a utility function with two main components: a systematic (observable) component and a random error term (non-observable). The DCE has become the most sought after tool for analyzing individual behavior and choice. While four main choice modeling alternatives (choice experiments, contingent ranking, contingent rating, and paired comparisons) are available, only the choice experiment provides outcomes consistent with standard welfare economics (Hanley *et al.*, 2001).

The DCE was first used in communication and transport studies (Louviere, 1981); however, its use gradually spread to other areas such as market research (Bastell & Louviere, 1991), environmental evaluation (Hanley *et al.*, 1998), identifying attributes of products influencing consumers (Lusk *et al.*, 2003), and agricultural multifunctionality (Kallas & Gómez-Limón, 2007). Windle & Rolfe (2005) used this methodology to analyze alternatives for agricultural diversification in Australia. This method has also found use in organic agriculture (Meas *et al.*, 2015), food traceability (Wu *et al.*, 2015), maintenance programs for plants and animals (Roessler *et al.*, 2008; Asrat *et al.*, 2010; Birol *et al.*, 2012), and provision of ecosystem services (Villanueva *et al.*, 2017). However, empirical applications of DCE regarding farming innovations are few.

Furthermore, Birol & Villalba (2006) noted that a successful application of DCE in developing countries such as Mexico depends on a careful selection of election sets and an effective compilation of field data. In Mexico, choice experiments have been used in natural reserves (Tudela *et al.*, 2009), trait selection of pig breeds (Scarpa *et al.*, 2003), and assessment of transgenic corn crops in the states of Jalisco, Michoacán, and Oaxaca (Birol & Villalba, 2006).

The choice modelling approach aims to identify the consumers' indirect utility function associated with the product attributes by examining the trade-offs they consider when making choices at a retail outlet. According to the random utility theory, the utility of an individual, *n*, choosing an alternative, j $(U_j^n, j=1, \ldots, J)$, is the sum of both 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. Furthermore, the individual, *n*, will choose the alternative, *j*, if it provides a utility that is superior over any other alternative, *i*, available in the choice set.

To predict a subject's preference for attribute *k*, we need to define the "probability of choice" that an individual *n* chooses the alternative *i* rather than the alternative *j* (for any *i* and *j* within choice set *T*). McFadden (1974) developed an econometric model that formalized respondents' decision-making process. This model is often referred to as the multinomial logit (MNL) model, which is considered the base model for DCE. In this model, the utility to person *n* from choosing alternative j on choice scenario t is given by:

$$U_{njt} = \beta x_{njt} + \varepsilon_{njt} / \sigma_n \qquad n = 1, \ \ldots, \ N$$
$$j = 1, \ \ldots, \ J \quad t = 1, \ \ldots, \ T \qquad [1]$$

where x_{njt} is a vector of observed attributes of alternative j, β is a vector of mean attribute utilities, and ε_{njt} is the "idiosyncratic" error term that follows independent and identically distributed (i.i.d.) type 1 extreme value distribution with scale parameter σ_n.

The probability $(P_j | X_{nt})$ that an individual *n* will choose alternative *j* among other alternatives in an array of choice set *T* is formulated as follows:

$$(P_j | X_{nt}) = \frac{\exp(\beta x_{njt})}{\sum_{j=1}^{J} \exp(\beta x_{njt})} \quad \forall j \in T \qquad [2]$$

where X_{nt} is the vector of attributes of all alternatives $j = 1, \ \ldots, \ J$. In the case of estimating a MNL, the scale parameter σ_n is normalized to 1 for identification.

However, this model imposes homogeneity in preferences for the observed attributes. Thus, only average attributes' utilities can be estimated. Therefore, the MIXL (Mixed Logit Model) has been introduced to investigate the unobserved heterogeneity. However, it has been argued that much of the preference heterogeneity in MIXL can be are better captured by the scale term and thus known as "scale heterogeneity" (Louviere & Mayer, 2007; Louviere *et al.*, 2008). According to Balogh *et al.* (2016), the scale heterogeneity might be interpreted as the variation of randomness in the decision-making process over respondents, *i.e.*, the variance of the error term (and hence the degree of certainty) may differ across individual decision-makers. This is especially relevant for the stated preference data, where respondents interpret choice situations differently and pay varying levels of attention to the task presented (Train & Weeks, 2005).

Among the various modeling approaches that include scale heterogeneity specification, Fiebig *et al.* (2010) proposed the GMNL model. According to this model, the utility of an individual, *n*, for selecting alternative, *j*, in a choice set, *t*, is given by

$$U_{njt} = [\sigma_n \beta + \gamma n_n + (1-\gamma)\sigma_n n_n] + \varepsilon_{njt} \quad [3]$$

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). Fiebig *et al.* (2010) proposed that σ_n follows a log-normal distribution with mean equal to 1 and standard deviation τ. The GMNL estimates the τ term that captures scale heterogeneity across respondents. Further details about GMNL specification and estimation can be found in Fiebig *et al.* (2010).

The usual procedure for calculating the WTP is estimating the distribution of utility coefficients and then deriving the distribution of WTP, which is the ratio of coefficients. However, Scarpa *et al.* (2008) described a method to estimate the distribution of WTP directly, which fits the data better, reduces the incidence of exceedingly large WTP values, and provides the analyst with greater control over the distribution of WTP. In the present study, we used the GMNL model in the WTP-space. In this case, the GMNL is reparametrized (Greene & Hensher, 2010) by separating the variable price, ρ, and its coefficient, βρ, *n*. By standardizing the price coefficient to 1, the WTP can be directly estimated. In this case, the mixing parameter (γ) turns to be a fixed parameter.

Finally, the DCE approach is similar to the PCE method used in this study (Greene, 2012). The only difference is that the choice variable used was proportional data rather than individual choice data. That is, the choice variable consists of a set of sample proportions with values ranging from 0 to 1. This variable should sum to 1 over the alternatives in the choice set. Observed proportions may be equal to 1 or 0 for some individuals if they answered 100% for some alternatives within the choice set.

Regarding the analysis of 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 popular approaches for analyzing observed heterogeneity. Besides the relevance of socioeconomic variables in describing preferences, this model also provides a way to obtain information regarding the different segments of the market. To illustrate, the model begins by contrasting the "segmentability" of the population studied. The LC determines the probability of an individual belonging to a certain class and the probability of choosing one alternative conditional on the preferences within each class. Further details regarding this model are available in Greene & Hensher (2003). In this study, we used the LC to analyze farmers' preferences. 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.

Empirical application

Data

Data was collected from face to face 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) and postal districts. Also, the interviews were made in a zone of potential corn production in the state of Chiapas: the towns of Villaflores, Chiapa 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, 2016). The sample size was calculated as finite populations with 95% as significance level NS and an error of 6.87%. Table 1 represents the survey technical sheet.

Following Kallas *et al.* (2010), the questionnaire was organized in two sections: the first included 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.

The applied proportional choice experiment (PCE)

The application of the PCE 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 this study, we placed 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 was, therefore, defined by the 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 begin with, we analyzed

Table 1. Survey technical sheet.

Population	Farmers over 18 years of age who are engaged in maize planting in the state of Chiapas			
Sample design	Stratified sample by seed variety and postal districts using proportional affixation to the number of persons by stratum			
Total sample	200			
Confidence level	95.5% (k=2)			
Control measure	Pilot survey (25 questionnaires)			
Date of field work	January- March 2015			
Field	The interviews were made in a zone of potential corn production in the state of Chiapas:			
	Villa de corzo	**Villa flores**	**Chiapa de corzo**	**Concordia**
Chiapas	3616	4255	896	2300
Sample size	65	77	16	42

the current farmer preferences when selecting crop seeds. The attributes that the farmers took into account when selecting a new variety are the corn ear shape (Ferro *et al.*, 2008), number of grains per row (Ferro *et al.*, 2008, 2013), corn ear filling arrangement (Ferro *et al.*, 2013), grain color (Soleri & Cleveland, 2001; Benz *et al.*, 2007), ear size (Ferro *et al.*, 2013; Sibiya *et al.*, 2013), ear height (Ferro *et al.*, 2008), ear weight (Ferro *et al.*, 2008; Sibiya *et al.*, 2013), 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.*, 2008, 2013), number of corn ears (Ferro *et al.*, 2008; Sibiya *et al.*, 2013), cob diameter (Herrera *et al.*, 2002), early maturity (Sibiya *et al.*, 2013), yield (Birol *et al.*, 2012; Ferro *et al.*, 2013; Sibiya *et al.*, 2013), grain size (Bellon & Risopoulos, 2001; Sibiya *et al.*, 2013), flavor (Sibiya *et al.*, 2013), tolerance to drought (Bellon *et al.*, 2006; Sibiya *et al.*, 2013), tolerance to excessive rain (Bellon *et al.*, 2006; Sibiya *et al.*, 2013), resistance to putrefaction of the corn ear (Bellon *et al.*, 2006; Sibiya *et al.*, 2013), duration (cycle of growth) (Bellon *et al.*, 2006; Sibiya *et al.*, 2013), plague resistance (Bellon *et al.*, 2006; Sibiya *et al.*, 2013), resistance to storage plagues (Bellon *et al.*, 2006; Sibiya *et al.*, 2013), and dough yield (Bellon *et al.*, 2006). The product price is another important extrinsic attribute affecting the purchase decision (Lockshin *et al.*, 2006).

The second step was to conduct a discussion group with researchers from the Instituto Nacional de Investigaciones Forestales, Agrícolas y Pecuarias (INIFAP, Mexico)[1] to reduce the primary information obtained. Also, this group evaluated and verified the suitability of attributes. Subsequently, a pilot questionnaire was applied to test the validity of the attributes and to determine the level of the price vector.

Regarding the cost attributes and levels, the price vector was based on the average prices for a bag of 20 kg of seed, provided by the INIFAP and the Secretaría de Agricultura, Ganadería, Desarrollo Rural, Pesca y Alimentación[2]. The price levels in the choice sets were selected to cover the central 90% of the observed values. However, the price was correlated with the type of seeds used. We used a labeled choice design to solve this problem, where each alternative choice was defined by the type of seed used. In Table 2, the main attributes and their levels are presented.

For the experimental design, forced and labeled choice sets representing the different varieties of maize seed were used. An efficient block design was used (ChoiceMetrics, 2014), leading to 27 choice sets classified into three groups. Respondents were asked to set their preferences for the different alternatives. No evidence was found in the pilot or main survey preferring to reject all corn types in a choice set.

Before beginning the survey, the choice experiment was explained orally and in writing. Respondents were asked to set the percentage of preference for the different varieties of seed for maize cultivation this year; thus, the dependent variable in this study was a proportion of two mutually exclusive alternatives in each choice set. An example of a choice set is shown in Fig. S1 [suppl].

[1] National Institute of Forestry, Agriculture and Livestock
[2] Office of the Secretariat of Agriculture, Livestock, Rural Development, Fisheries, and Food

Table 2. 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. t/ha) Medium (2.6-3.7 t/ha) High (3.8-5.0 t/ha)	Low (6.0-9.0 t/ha) Medium (9.1-12 t/ha) High (12.1-15.0 t/ha)
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 kg of seed

Table 3. Corn grower socio-demographic profile.

Variables	Sample	Total farmers in Chiapas
	Mean (%)	Mean 2015 (%)
Gender	23.0	31.7
Female	77.0	68.3
Male		
Level of education	58.1	14.6
No schooling	25.3	57.2
Low level of education	16.6	28.2
Mid-level education		
Property right	72.0	54.9
Ejido land[1]	25.0	39.3
Small property	2.0	1.2
Hired	1.0	4.6
Communal		
Age	36.5	58.6
[20-50] years	63.5	38.6
[51-92] years		
Hectares	77.5	41.0
[0.1-5]	21.5	49.0
[5.1-20]	1.0	10
[>20]		

[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 and discussion

Farmers' preferences on improved seeds

Table 3 represents a summary of the major sociodemographic characteristics of the respondents. The proportion of each stratum is similar across the population of farmers in the geographical area surveyed.

Results of the GMNL model in the WTP-space are shown in Table 4. The model showed a goodness-of-fit with an acceptable value of McFadden pseudo R^2 that is equal to 0.169, similar to other studies that analyzed farmers' preferences through choice experiments (Birol & Villalba, 2006; Kallas & Gómez-Limón, 2007; Ortega *et al.*, 2016). The log likelihood ratio was also highly significant at 99%. Results showed that the estimated coefficients of the majority of the levels of attributes are statistically significant. This result confirms that most of the attributes and levels considered in the model are significant and essential in predicting farmers' preferences.

The estimated parameters directly provide information about the WTP. These estimates should be multiplied by 100 as the price variable was divided by 100 during the estimation. Farmers showed a positive WTP for crop yield. The same trend occurred among the attributes of resistance to disease and ear length. Corn growers were willing to pay $15.80 for a 20 kg bag of improved corn seed to gain one centimeter in corn ear length. These results are in agreement with the findings of Kassie *et al.* (2017). Maize varieties with medium- and large-sized cobs are preferred as the cob size has a lot to do with grain yield and marketability.

Furthermore, farmers were willing to pay $2.90 more to gain 1% of resistance to disease in the maize crop, and $39.89 more per bag to increase the crop yield by 1 ton. However, unexpectedly, the respondents did not give importance to the attribute "height of the corn,", despite the problems that this characteristic can cause. Nevertheless, in conformity with the finding of Hellin & Bellon (2007), farmers gave more importance to corn stems for making fences and leaves as forage. Therefore, any corn type can be grown for forage, but the ones with a higher yield of biomass are the tall varieties. On the other hand, improved varieties have a little bud sport and usually produce less forage per unit of area (Estrada *et al.*, 2015); thus, farmers are willing to accept a tall plant as long as it has a high yield and wind-resistant stalk.

In addition, the estimated coefficient of the alternative specific constant (ASC) of the improved corn was not significant. This result shows that the attributes and levels that were not included in describing corn may not be relevant.

Our results are consistent with other studies that considered high yields, resistance to diseases, and lower price as main drivers for selecting improved seeds

Table 4. Results of the GMNL in WTP- Space model for corn growers in Chiapas.

Attributes	β[a]	*p* value
	Random parameters in utility functions	
Price	1.0 .....(Fixed parameter).....	
Corn ear length	0.1580***	0.000
Corn stalk height	0.0273	0.797
Resistance to disease	0.0290***	0.000
Yield	0.3989***	0.000
ASC of improved seed	0.1209	0.540
	Variance parameter tau	
Variance parameter tau in scale parameter	3.7641***	0.000
	Mixing parameter	
Mixing parameter gamma	0.000........(Fixed parameter)......	
Log likelihood function	-1.036.13	
Restricted log likelihood	1.247.66	
Pseudo-R^2	0.169	

GMNL: generalized multinomial logit. WTP: willingness to pay. ASC: alternative specific constant. [a]: For the interpretation of results, the estimated WTP should be multiplied by 100 as the price variable was divided by 100. Significance levels: *** $p<0.01$.

(Asrat *et al.*, 2010; Sibiya *et al.*, 2013; Waldman *et al.*, 2017).

According to Ajambo *et al.* (2010), corn farmers in Uganda preferred drought-resilient varieties, with a short growth cycle and higher resistance to pests and diseases. Those farmers were willing to pay Ush 200–5,000/kg for a variety with such characteristics (1 US$ = 2,200 Ugandan USh). Comparatively, Kassie *et al.* (2014) pointed out that Zimbabwean farmers were willing to pay 1.75 times more to ensure tolerance to drought and a harvest of one more ton of crop. It was 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, the seed cost was also an important factor describing preferences. Our results are similar to those of other studies where the cost of seed is a main determining factor when choosing a variety (Kyeyune & Turner, 2016). Kassie *et al.* (2017) indicated that the trait-based promotion and marketing of varieties constitutes a suitable strategy for the adoption of improved corn seeds.

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 our study show that the farmers demonstrate a high level of product uncertainty and randomness when choosing corn seed (Fleming *et al.*, 2016).

Farmers' observed heterogeneity toward corn seed preference

A LC model was used to analyze farmers' observed heterogeneity. This model allowed us to classify corn growers into three types according to their preferences. The optimal number of segments, the BIC, the pseudo R^2, and probability of the result of each segment were computed (Hu *et al.*, 2004). Therefore, the LC model with three classes was selected as the best fit. Out of 200 farmers surveyed, we found that 60.5% are innovators, 29.4% are transition farmers, and 10% are conservative (Table 5).

Table 5. Results of the latent class model

	Coefficient	Prob.
Innovators (Latent class 1)	Utility parameters for innovators (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 for innovators (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	-0.01	0.9077
Conservative farmers (Latent class 3)	Utility parameters for conservative (3)	
Corn ear length	0.09***	0.0082
Corn stalk height	0.13	0.5919
Resistance to disease	0.01	0.3907
Yield	0.08	0.1300
ASC improved seed	-2.17***	0.0000
Price	-0.05*	0.0836
Estimated latent class probabilities		
Prob. Innovators	0.60***	
Prob. Transition	0.29***	
Prob. 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 costant

The first latent class was innovators who gave much importance to seed yield, resistance to diseases, and price. This segment is the most price-sensitive. The second latent class, transition farmers, considered yield as the most important attribute, followed by a lower preference for intensive seed type. Our results were similar to those of Ortega *et al.* (2016) who reported that Malawian farmers have a strong positive preference for maize grain yield. The third latent class, conservative farmers, considered improved seeds as unimportant; instead, they preferred creole seeds and gave importance to a large corn ear and seed price.

For classes 1 and 2, the ASCs were positive, but the ASC of class 3 were negative, which could have been due to the residual 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 preference for improved seeds if these met the preferred attributes.

Finally, the price had negative effects; that is, the lower the price, the higher is the utility for farmers, and so a normal demand was consistent. It is important to stress how important fertilizers are when using improved seeds, because fertilizers are necessary to obtain better yields. The amount of fertilizer used is considerably higher when using improved seeds than when growing creole varieties (Bernard *et al.*, 2010). In this respect, Gecho & Punjabi (2011) pointed out that the price of fertilizer lowers the probability of the adoption of improved corn. Furthermore, Salgado & Miranda (2010) stressed that the increase in corn productivity in Mexico in the coming years will be subject to the price of fertilizers.

Profile of corn farmer segments

Knowing the types of farmers who 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 sociodemographic characteristics. These characteristics included the farmer's age, number of generations in agriculture, number of generations in corn farming, year responsible for managing the exploitation, and year when corn farming began. Besides these sociodemographic variables, we also collected data relating 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 using a 11-point scale, where 0 suggested that the farmer considers the soil to be of bad quality, and 10 suggested that the farmer considers the soil to be of excellent quality.

Table 6. 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)	56[b]	55[b]	67[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 (%)	98.5[a]	83.9[b]	89.9[b]
Total surface (ha)	5.1[a]	4.2[a]	2.6[b]
Yield (t/ha)	4.0[a]	3.6[a]	2.2[b]
Quantity sold (kg/ha)	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]	Intermediatea[b]	Averse[b]
Source of information used	Technicians of commercial establishments[a]	Employees[a]	Family members[b]

[a, b, c,] Statistical differences among the different corn farmer groups at 95 %.

Attitudes, opinions, and perceptions toward risk also play an important role in determining the adoption of seed varieties (Howley *et al.*, 2015). Thus, in our profiling analysis, we also included the perception towards improved seed and risk attitude. Risk attitudes and opinions toward improved seeds were assessed via two principal component analyses (PCA) following the previous studies (Asrat *et al.*, 2010; Birol *et al.*, 2012; Li *et al.*, 2012; Valdivia *et al.*, 2015). Table 6 shows the profiles of different segments.

According to our analyses, innovators were 56 years on average. They started cultivating corn in 1980 and showed acceptance of improved seeds. These farmers mainly cultivated improved seeds with a higher yield per hectare and achieved higher sales. These farmers own more land, consistent with Kalinda *et al.* (2014) finding that improved corn seed use is directly related to the size of land owned. However, these farmers are risk acceptors, as they had more resources to mitigate the effects of risks when adopting new technologies. Transaction costs per surface unit were lower than that for farmers owning small areas, consistent with the findings of Paredes & Martin (2007) study.

In contrast, transition farmers were aged 55 on average 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. They tried to use improved seeds on an experimental scale in their farms.

Finally, conservative farmers were 67 years on average and had more experience in crop management (they have been growing corn since 1971). This group of farmers used 89.9% of corn production for sales and the remainder for their own consumption. Most of them used creole seeds with lower yield, implemented smaller crops, and traveled a longer distance from their homes to their fields. These farmers were risk-averse, wherein their family members represented the main source of farming information. Thus, access to information can reduce uncertainty about the possible results of using new technology, as also noted by Honra *et al.* (2007). 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).

Our results were similar to those of Villanueva *et al.* (2017), who compared the characteristics of three groups of olive farmers in Andalusia, Spain (protesters, very high takers, and participants).

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.

Our 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. In all cases, it is worth mentioning that the results should be taken with caution because of the sample characteristics and the relatively low goodness of fit of the model to data.

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. 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.

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References

Ajambo R, Bashaasha B, Okori P, Elepu G, 2010. Producer and consumer preferences for maize and sorghum quality characteristics in Uganda. II RUFORUM Bienn Reg Conf on" Building capacity for food security in Africa". RUFORUM (Entebbe, Uganda), Sept 20-24. pp: 1627-1631.

Asrat S, Yesuf M, Carlsson F, Wale E, 2010. Farmers' preferences for crop variety traits: Lessons for on-farm conservation and technology adoption. Ecol Econ 69 (12): 2394-2401. https://doi.org/10.1016/j.ecolecon.2010.07.006

Balogh P, Békési D, Gorton M, Popp J, Lengyel P, 2016. Consumer willingness to pay for traditional food products. Food Policy 61: 176-184. https://doi.org/10.1016/j.foodpol.2016.03.005

Bastell R, Louviere J, 1991. Experimental analysis of choice. Market Lett 2 (3): 199-214. https://doi.org/10.1007/BF02404072

Bellon M, 1991. The ethnoecology of maize variety management: A case study from Mexico. Human Ecol 19 (3): 389-418. https://doi.org/10.1007/BF00888984

Bellon M, Risopoulos J, 2001. Small-scale farmers expand the benefits of improved maize germplasm: A case study from Chiapas, Mexico. World Dev 29 (5): 799-811. https://doi.org/10.1016/S0305-750X(01)00013-4

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 Dev 34 (1): 113-129. https://doi.org/10.1016/j.worlddev.2005.05.012

Benz B, Perales H, Brush S, 2007. Tzeltal and Tzotzil farmer knowledge and maize diversity in Chiapas, Mexico. Curr Anthropol 48 (2): 289-300. https://doi.org/10.1086/512986

Bernard M, Hellin J, Nyikal R, Mburu J, 2010. Determinants for use of certified maize seed and the relative importance of transaction costs. Joint 3rd Afr Assoc Agr Econ and 48th Agr Econ Assoc of South Africa Conf. Cape Town, South Africa, Sept 19-23. pp: 1-26.

Birol E, Villalba E, 2006. Estimating Mexican farmers' valuation of Milpa diversity and genetically modified maize: A choice experiment approach. Environ Econ Policy Res Working Papers, 21.

Birol E, Smale M, Gyovai A, 2006. Using a choice experiment to estimate farmers' valuation of agrobiodiversity on Hungarian small farms. Environ Resour Econ 34: 439-469. https://doi.org/10.1007/s10640-006-0009-9

Birol E, Villalba E, Smale M, 2009. Farmer preferences for milpa diversity and genetically modified maize in Mexico: a latent class approach. Environ Dev

Econ 14 (4): 521-540. https://doi.org/10.1017/S1355770X08004944
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.
Castillo J, Chávez C, 2013. Caracterización campesina del manejo y uso de la diervisad de maíces en San Felipe del Progreso, estado de México. Agricultura, Sociedad y Desarrollo 10 (1): 23-38.
ChoiceMetrics, 2014. Ngene 1.1.2 User manual and reference guide, Australia. 248 pp.
Copeland O, McDonald M, 2001. Principles of seed science and technology. Springer Science & Business Media, Massachusetts, USA. 467 pp. https://doi.org/10.1007/978-1-4615-1619-4
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.
Ferro M, Ríos H, Chirino E, Márquez M, Valdés RJ, Suárez Y, Alfaro F, 2008. Entendiendo el sistema informal de semilla de maíz cubano. La selección de variedades de maíz (Zea mays, Lin) por campesinos de La palma, Pinar del Rio. Cultivos Tropicales 29 (1): 61-68.
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.
Fiebig G, Keane P, Louviere J, Wasi N, 2010. The generalized multinomial logit model: Accounting for scale and coefficient heterogeneity. Market Sci 29 (3): 393-421. https://doi.org/10.1287/mksc.1090.0508
Fleming K, Kouassi A, Ondula E, Waweru P, 2016. Toward farmer decision profiles to improve food security in Kenya. IBM J Res Dev 60 (5/6): 6-10. https://doi.org/10.1147/JRD.2016.2592278
Gecho Y, Punjabi K, 2011. Determinants of adoption of improved maize technology in Damot Gale, Wolaita, Ethiopia. Rajasthan J Extens Educ 19 (1): 1-9.
Greene H, 2012. Reference guide of the NLOGIT 5, Econometric Software, Inc., NY.
Greene W, Hensher D, 2003. A latent class model for discrete choice analysis: contrasts with mixed logit. Transport Res B: Meth 37 (8): 681-698. https://doi.org/10.1016/S0191-2615(02)00046-2
Greene H, Hensher A, 2010. Does scale heterogeneity across individuals matter? An empirical assessment of alternative logit models. Transportation 37 (3): 413-428. https://doi.org/10.1007/s11116-010-9259-z
Hanley N, Wright R, Adamowicz V, 1998. Using choice experiments to value the environment. Environ Resour Econ 11 (3-4): 413-428. https://doi.org/10.1023/A:1008287310583
Hanley N, Mourato S, Wright E, 2001. Choice modelling approaches: a superior alternative for environmental valuation? J Econ Surv 15 (3): 435-462. https://doi.org/10.1111/1467-6419.00145
Harrison P, 2002. Agricultura mundial: hacia los años 2015/2030. Servicio de Publicaciones y Multimedia. Dirección de Información de la FAO.
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. https://doi.org/10.1016/j.foodpol.2012.02.005
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. Agron J 104 (5): 1413-1424. https://doi.org/10.2134/agronj2012.0087
Horna D, Smale M, Oppen V, 2007. Farmer willingness to pay for seed-related information: Rice varieties in Nigeria and Benin. Environ Dev Econ 12 (6): 799-825. https://doi.org/10.1017/S1355770X07003956
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. Ecol Econ 109: 186-193. https://doi.org/10.1016/j.ecolecon.2014.11.015
Hu W, Hunnemeyer A, Veeman M, Adamowicz W, Srivastava L, 2004. Trading off health, environmental and genetic modification attributes in food. Eur Rev Agr Econ 31 (3): 389-408. https://doi.org/10.1093/erae/31.3.389
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 (July 15, 2016)
Kalinda T, Tembo G, Kuntashula E, 2014. Adoption of improved maize seed varieties in Southern Zambia. Asian J Agr Sci 6 (1): 33-39.
Kallas Z, Gómez-Limón J, 2007. Agricultural multifunctionality valuation : A case study using the choice. Estud Econ Aplic 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. Agr Econ 41 (5): 409-423. https://doi.org/10.1111/j.1574-0862.2010.00454.x

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 An Conf, AgroParisTech, Paris, France. April 9-11, pp: 1- 27.

Gecho Y, Punjabi K, 2011. Determinants of adoption of improved maize technology in Damot Gale, Wolaita, Ethiopia. Rajasthan J Extens Educ 19 (1): 1-9.

Greene H, 2012. Reference guide of the NLOGIT 5, Econometric Software, Inc., NY.

Greene W, Hensher D, 2003. A latent class model for discrete choice analysis: contrasts with mixed logit. Transport Res B: Meth 37 (8): 681-698. https://doi.org/10.1016/S0191-2615(02)00046-2

Greene H, Hensher A, 2010. Does scale heterogeneity across individuals matter? An empirical assessment of alternative logit models. Transportation 37 (3): 413-428. https://doi.org/10.1007/s11116-010-9259-z

Hanley N, Wright R, Adamowicz V, 1998. Using choice experiments to value the environment. Environ Resour Econ 11 (3-4): 413-428. https://doi.org/10.1023/A:1008287310583

Hanley N, Mourato S, Wright E, 2001. Choice modelling approaches: a superior alternative for environmental valuation? J Econ Surv 15 (3): 435-462. https://doi.org/10.1111/1467-6419.00145

Harrison P, 2002. Agricultura mundial: hacia los años 2015/2030. Servicio de Publicaciones y Multimedia. Dirección de Información de la FAO.

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. https://doi.org/10.1016/j.foodpol.2012.02.005

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. Agron J 104 (5): 1413-1424. https://doi.org/10.2134/agronj2012.0087

Horna D, Smale M, Oppen V, 2007. Farmer willingness to pay for seed-related information: Rice varieties in Nigeria and Benin. Environ Dev Econ 12 (6): 799-825. https://doi.org/10.1017/S1355770X07003956

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. Ecol Econ 109: 186-193. https://doi.org/10.1016/j.ecolecon.2014.11.015

Hu W, Hunnemeyer A, Veeman M, Adamowicz W, Srivastava L, 2004. Trading off health, environmental and genetic modification attributes in food. Eur Rev Agr Econ 31 (3): 389-408. https://doi.org/10.1093/erae/31.3.389

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 (July 15, 2016)

Kalinda T, Tembo G, Kuntashula E, 2014. Adoption of improved maize seed varieties in Southern Zambia. Asian J Agr Sci 6 (1): 33-39.

Kallas Z, Gómez-Limón J, 2007. Agricultural multifunctionality valuation : A case study using the choice. Estud Econ Aplic 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. Agr Econ 41 (5): 409-423. https://doi.org/10.1111/j.1574-0862.2010.00454.x

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 An Conf, AgroParisTech, Paris, France. April 9-11, pp: 1- 27.

Kassie G, Abdulai A, Greene H, Shiferaw B, Abate T, Tarekegne A, Sutcliffe C, 2017. Modeling preference and willingness to pay for drought tolerance (DT) in maize in rural Zimbabwe. World Dev 94 (1): 465-477. https://doi.org/10.1016/j.worlddev.2017.02.008

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. https://doi.org/10.1016/j.geoforum.2016.03.001

Lancaster J, 1966. A new approach to consumer theory. J Polit Econ 74(2): 132-157. https://doi.org/10.1086/259131

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. Genet Resour Crop Evol 59 (6): 1147-1160. https://doi.org/10.1007/s10722-011-9750-1

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 Qual Prefer 17 (3-4): 166-178. https://doi.org/10.1016/j.foodqual.2005.03.009

Louviere J, 1981. Laboratory simulation vs. revealed preference methods for estimating travel demand models: an empirical comparison. Transport Res Rec 794: 42-51.

Louviere J, 2001. Choice experiments: an overview of concepts and issues. In: The choice modelling approach to environmental valuation; Bennett J & Blarney R (Eds). E. Elgar Publ. UK. pp: 1-36.

Louviere J, Meyer R, 2007. Formal choice models of informal choices: What choice modeling research can (and can't) learn from behavioral theory. In: Review of Marketing Research; Malhotra NK ed. M. E. Sharpe, NY. pp: 3-32.

Louviere J, Street D, Burgess L, Wasi N, Islam T, Marley A, 2008. Modelling the choices of individuals decision makers by combining efficient choice experiment designs with extra preference information. J. Choice Model 1 (1): 128-163. https://doi.org/10.1016/S1755-5345(13)70025-3

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. Am J Agr Econ 85 (1): 16-29. https://doi.org/10.1111/1467-8276.00100

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.

McFadden D, 1974. Conditional logit analysis of qualitative choice behavior. In: Frontiers in econometrics; Zarembka P, (Ed). Academic Press, NY.

Meas T, Hu W, Batte M, Woods T, Ernst S, 2015. Substitutes or complements? Consumer preference for local and organic food attributes. Am J Agr Econ 97 (4): 1044-1071. https://doi.org/10.1093/ajae/aau108

Morris L, Bellon M, 2004. Participatory plant breeding research: Opportunities and challenges for the international crop improvement system. Euphytica 136 (1): 21-35. https://doi.org/10.1023/B:EUPH.0000019509.37769.b1

Nelson C, Rosegrant W, Koo J, Robertson R, Sulser T, Zhu T, Ringler C, Msangi S, Palazzo A, Batka M, *et al.*, 2009. Cambio climático: El impacto en la agricultura y los costos de adaptación. IFPRI. 28 pp.

Ortega L, Waldman B, Richardson B, Clay C, Snapp S, 2016. Sustainable intensification and farmer preferences for crop system attributes: Evidence from Malawi's Central and Southern Regions. World Dev 87 (1): 139-151. https://doi.org/10.1016/j.worlddev.2016.06.007

Paredes C, Martin A, 2007. Adoption of transgenic crops by smallholder farmers in Entre Rios, Argentina. Proc of 2007 AAEA WAEA & CAES Joint Annual Meeting. Portland, OR, USA, Jul 29-Aug 1, pp: 1-26.

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. Ecol Econ 66 (1): 184-192. https://doi.org/10.1016/j.ecolecon.2007.08.023

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. Ecol Econ 45 (3): 427-443. https://doi.org/10.1016/S0921-8009(03)00095-8

Scarpa R, Thiene M, Train K, 2008. Utility in willingness to pay space: A tool to address confounding random scale effects in destination choice to the Alps. Am J Agr Econ 90 (4): 994-1010. https://doi.org/10.1111/j.1467-8276.2008.01155.x

SIAP, 2016. Avances de siembras y cosechas por estado y año agrícola. Secretaría de Agricultura, Ganadería, Desarrollo Rural, Pesca y Alimentación. http://infosiap.siap.gob.mx:8080/agricola_siap_gobmx/ResumenProducto.do [March 15, 2016].

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. J Agr Rur Dev Trop Subtrop 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. Econ Bot 55 (1): 106-128. https://doi.org/10.1007/BF02864550

Spielman DJ, Davis K, Negash M, Ayele G, 2011. Rural innovation systems and networks: findings from a study of Ethiopian smallholders. Agr Hum Values 28: 195-212. https://doi.org/10.1007/s10460-010-9273-y

Thurstone L, 1927. A law of comparative judgement. Psychol Rev 34: 273-286. https://doi.org/10.1037/h0070288

Train K, Weeks M, 2005. Discrete choice models in preference space and willingness-to-pay space. In: Applications of simulation methods in environmental and resource economics; Alberini A, Scarpa R. (eds). New Zeland. pp: 1-16. https://doi.org/10.1007/1-4020-3684-1_1

Tudela W, Martínez A, Valdivia R, Portillo M, Romo L, 2009. Modelos de elección discreta en la valoración económica de áreas naturales protegidas. Revista Mexicana de Economía Agrícola y de los Recursos Naturales 2 (3): 7-29.

Turrent A, Wise T, Garvey E, 2012. Factibilidad de alcanzar el potencial productivo de maíz de México. Mex Rur Dev Res Rep, pp: 1-32.

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

Villanueva J, Glenk K, Rodríguez-Entrena M, 2017. Protest responses and willingness to accept: Ecosystem services providers' preferences towards incentive-based schemes. J Agr Econ, DOI: 10.1111/1477-9552.12211. https://doi.org/10.1111/1477-9552.12211

Waldman B, Ortega L, Richardson B, Snapp S, 2017. Estimating demand for perennial pigeon pea in Malawi using choice experiments. Ecol Econ 13: 222-230. https://doi.org/10.1016/j.ecolecon.2016.09.006

Windle J, Rolfe J, 2005. Diversification choices in agriculture: A choice modelling case study of sugarcane growers. Aust J Agr Resour Econ 49 (1): 63-74. https://doi.org/10.1111/j.1467-8489.2005.00279.x

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. Chin Econ Rev 35: 121-136. https://doi.org/10.1016/j.chieco.2015.07.001