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Small-scale farmers' willingness to adopt chemical-free inputs and engage in collaborative arrangements –A discrete choice experiment in Central Mexico

Disposición de los pequeños agricultores a adoptar insumos libres de químicos y a involucrarse en acuerdos colaborativos –Un experimento de elección discreta en la zona centro de México.

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Abstract

Objetive: Explore small-scale Mexican farmers' willingness to adopt chemical-free fertilizers and pesticides, and to engage in two collaborative arrangements.
Methodology: A discrete choice experiment has been designed based on two non-monetary attributes (use/no use of chemical inputs and two collaborative arrangements) and a monetary attribute (percentage change in price of crop that generates most of net revenues). Data has been analyzed with a two-class latent class logit specification.
Findings: 60% of respondents is not willing to transition to a chemical-free input regime, is willing to receive management support from municipality, and is not interested in a shared insurance. On the opposite side of the preferences, 40% of respondents is willing to adopt chemical-free inputs, is not interested in management support, and is willing to participate in a shared insurance.
Limitations: Our sample is not nationally representative, and further studies are needed to corroborate and generalize our findings.
Contribution: This is the first study exploring whether preferences of small-scale farmers in Mexico align with Federal government's goal of phasing out glyphosate.
Conclusions: With 40% of small-scale farmers willing to adopt chemical-free inputs, if the Federal government wants to convice the other 60% of phasing out glyphosate, a possibility is to implement a slower strategy that starts with providing management support. Once management support is in place, and trust is gained, doors may open for a transition to chemical-free production regimes.
Key words: Chemical-free inputs, collaborative arrangements, discrete choice experiment, latent class logit, small-scale farmers, Mexico
JEL classifications: Q13, Q52, Q20, Q12

Resumen

Objetivo: Investigar la disposición de los agricultores de pequeña escala en México a adoptar insumos libres de químicos y a involucrarse en dos acuerdos colaborativos.
Metodología: Se ha diseñado un experimento de elección discreta que contiene dos atributos no pecuniarios (uso/no uso de insumos químicos, y dos acuerdos colaborativos) y un atributo pecuniario (cambio porcentual en el precio del cultivo que genera los mayores ingresos netos del encuestado). Los datos han sido analizados mediante un logit con dos clases latentes.
Resultados: 60% of encuestados no está dispuesto a utilizar insumos libres de químicos, está interesado en recibir apoyo administrativo del municipio, y no está interesado en un seguro compartido. Por otra parte, 40% de los encuestados está interesado en usar insumos libres de químicos, no está interesado en el apoyo administrativo, y está dispuesto a participar en un esquema de seguro compartido.
Limitaciones: Nuestra muestra no es representativa a nivel nacional, por lo que es necesario llevar a cabo estudios que corroboren y generalicen los resultados reportados en este artículo.
Contribución: Éste es el primer estudio que investiga si las preferencias de los agricultores de pequeña escala en México coinciden con el objetivo la administración Federal de eliminar el uso del glifosato en actividades agropecuarias.
Conclusiones: Dado que 40% de los encuestados está dispuesto a adoptar insumos libres de químicos, si la administración Federal quisiera persuadir al restante 60% de la conveniencia de eliminar el glifosato, una posibilidad es implementar una estrategia más lenta que provea apoyo administrativo. Una vez que este apoyo fluya, y el gobierno tenga la confianza de los agricultores, es posible discutir acuerdos colaborativos que permitan una transición a una agricultura libre de químicos.
Palabras clave: Insumos libres de químicos, acuerdos colaborativos, experimento de elección discreta, logit con clases latentes, agricultores de pequeña escala, México.
Clasificación jel: Q13, Q52, Q20, Q12.

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Introduction

Farmers worldwide rely on chemical inputs such as fertilizers, pesticides, and herbicides. Unfortunately, chemical inputs increase productivity at the expenses of, among other resources, soil quality (Reynolds et al., 2007); coastal wetlands (Benett et al, 2018); bird populations (Benett et al, 2018; Alló et al., 2015); terrestrial biodiversity (Navntoft et al., 2009); and human health (Khan et al., 2015).

Instances of such a trade-off are abundant in Mexico. For example, residues of pesticides have been detected i) in pygmy owls captured near the Protected Natural Area Cerro Sonsonate, Chiapas (Arrona-Rivera et al., 2016); ii) in bottled drinking water in Mexico City with three types of these pesticides at higher than the recommended levels (Diaz et al., 2009); and iii) in three types of fish in the Navachiste Lagoon, Sinaloa (Granados-Galván, 2015).

In this context, the Mexican federal government is taking steps to reduce chemical components involved in the production of food for human consumption. According to a federal decree issued in Decemeber 31, 2020, Mexico is aiming to gradually phase out the use of glyphosate, aiming to a full prohibition in 2024 (DOF, 2020).

A question that naturally arises is whether farmers' preferences align with Federal government's goal of phasing out the use of glyphosate –i.e. are Mexican farmers interested in adopting chemical-free inputs? This paper explores this issue by gathering and analyzing small-scale farmers' preferences by means of a discrete choice experiment (DCE), which is a survey-based method requesting, in this application, that farmers indicate their favorite alternative from among two hypothetical scenarios described in terms of three attributes.[1] The first attribute refers to type of inputs –chemical-free or conventional chemical. The second attribute refers to collaborative arrangements. A collaborative arrangement is a risk- sharing strategy that may decrease negative externalities from farming practices (Andersson et al., 2005). We explore farmers' preferences for two collaborative arrangements. The first arrangement is described as the possibility that the municipality provides management support to farmers who would be the main managers. The second arrangement is described as an insurance scheme shared by farmers. The third attribute in our DCE is a monetary attribute, described as a percentage change in price of the crop that represents the majority of a farmer's net revenues. Inclusion of a monetary attribute in a DCE enables practitioners to translate decisions reported by respondnets into monetary values by taking advantage of the implicit rate of substitution between non-monetary attributes and money –see section 3 of this paper for details on this point.

Respondents to our DCE are 146 small-scale farmers that use chemical inputs in their production process, and trade their products in small markets (tianguis) located in Central Mexico –in Estado de Mexico, Puebla, and Queretaro, which are states surrounding Mexico City. In deciding the specific location of the markets where farmers were invited to answer our survey, we have kept in mind that a guiding recommendation when implementing a stated preferences study is to make sure that respondents relate to the market that is under simulation (Johnston et al., 2017). In our study, potential respondents may not necessarily find easy to ponder scenarios under which only chemical-free inputs are allowed –because, by design, respondents to our DCE lack experience with farming practices that rely on chemical-free inputs. To address this issue, we have approached farmers that trade their products in markets located in close proximity to organic markets –i.e. markets where traded products have been produced under a chemical-free regime. Our respondents are aware of the organic market closest to

1 See Johnston et al. (2017) for a general description of DCE

them. Arguably, this recruitment strategy increases the chances that our respondents, while still using chemical inputs, are aware of farming practices that rely on chemical-free inputs.

We report findings from a latent class logit specification, which illustrates that farmers have heterogeneous preferences across groups.[2] In this application, we document that a group of farmers that represent 40% of respondents is interested in adopting chemical-free inputs. We have taken advantage that latent class models can accommodate a *membership* equation –i.e. a equation that models the probability that a respondent belog to, in this case, the group that is interested in adopting chemical-free inputs. This membership equation suggests that social cohesion, education, and farming experience are all three associated positively with the probability of belonging to the group that is interested in chemical-free inputs.

The contribution of this paper is twofold. On one hand, it contributes to inform a national conversation. To the best of our knowledge, neither academic researchers nor policy makers have previously explored whether preferences of small-scale farmers in Mexico align with Federal government's goal of phasing out the use of glyphosate.[3] In particular, as our data was gathered in 2017 and the official phasing out of glyphosate was announced in 2020, findings reported in this study can be interpreted as baseline numbers that provide context to reactions such as the National Agricultural Council' opposition to phasing out glyphosate (El Siglo de Torreon, 2021) –National Agricultural Council is the leading institution representing interests of agricultural businesses in Mexico.

On the other hand, this paper also contributes to a broader literature that has gathered stated preferences to document farmers' preferences for farming practices that may align with Sustainable Development Goals (SDGs) –in particular, SDG 12 (responsible production and consumption), SDG 14 (life below water), and SDG 15 (life on land). To the best of our knowledge, this broader literature has mostly focused on preferences of farmers located in developed countries, with a focus in Europe –e.g. Blasch et al. (2022) in Italy, Christensen et al. (2011) in Denmark, Jaeck and Lifran (2014) in France, and Tur-Cardona et al. (2018) in seven different European countries. Farmers' stated preferences for sustainable farming practices have been explored to a lesser extend in Asia –e.g. Bennett et al. (2018) in China, and Khan and Damalas (2015) in Pakistan. Latin America and Africa have largely been overlooked by studies exploring stated preferences of farmers for sustainable farming practices.

Previous DCE studies documenting farmer's preferences for chemical-free inputs and/or a collaborative component

In this section, we focus on studies implementing discrete choice experiments (DCEs) to analyze farmers' preferences for chemical-free inputs and/or a collaborative component.

Farmers' preferences for chemical-free inputs have been documented by several discrete choice experiment (DCE) studies in broader contexts such as environmentally-friendly farming practices and agri-environmental schemes (AES). This literature is large by now and has focused on a wide range of attributes such as arable crop

2 See section 3 of this paper for details on latent class logit specifications.

3 In this respect, our motivation is shared by Martínez-Cruz and Núñez (2021), who implement a DCE on urban residential electricity consumers in Aguascalientes, Mexico. Their study is justified on the basis that despite a heated debate about Mexico's energy transition, neither academic researchers nor policy makers have explored whether electricity end-users' preferences are aligned with current Federal government's goals.

diversity (Schulz et al., 2014), cover crops (Villanueva et al., 2015), labor intensity (Vidogbéna et al., 2015), length and flexibility of AES contracts (Greiner, 2016; Ruto and Garro, 2009), administrative load (Ruto and Garrod, 2009), compulsory technical training (Espinosa-Goded et al., 2010), agency funding the AES (Greiner et al., 2014), and agency monitoring AES (Greiner, 2015).

Preferences of farmers in developed countries –Europe, in particular— have been the main focus of the specific body of literature that has impleted DCE to explore interest for chemical- free fertilizers/pesticides. In the context of a Danish AES, Christensen et al. (2011) present farmers to a DCE in which the pesticide attribute is described in terms of pesticide-free buffer zones –i.e. attribute levels are i) fertilizers are allowed, and ii) pesticides and artificial manure are not allowed. Using the most restrictive pesticide category as a baseline, the authors report that farmers are willing to give up 125 US dollars/ha/year if they can use fertilizers.

Focusing on the Camargue Region, France, Jaeck and Lifran (2014) assess rice farmers' preferences for weed control practices which are described as a four-level attribute in the DCE. The levels vary in the chemical intensity. The most chemical-intensive level implies three applications or more. The second level implies at most two applications. The third and fourth levels are chemical-free as they are described as mechanical weeding and manual weed removal, respectively. They document heterogeneity in preferences via a latent class specification yielding three groups of farmers. A group representing only 10% of the sample reports preferences for mechanical and manual weeding over the chemical alternatives. The other two groups, representing 90% of the sample, report unwillingness to transition to a chemical-free regime.

Tur-Cardona et al. (2018) have elicited farmers' preferences for attributes of bio-based fertilizers in seven European countries –Belgium, Denmark, France, Netherlands, Germany, Hungary, and Croatia. They document that farmers across those countries prefer feritlizers as similar as possible to their current chemical fertilizer. Deviations from a preferred product would need to be compensated by lower prices. Important when it comes to modelling adoption of sustainable farming practices, the authors document that 10% of respondents always indicated their preference for their current fertilizer.

Focusing on the German context, Danne et al. (2019) point out that glyphosate plays an important role in farmer's strategic decision for reducing weed pressure and yield losses. They use a DCE that considers use of glyphosate as part of a complete agronomic strategy that involves farmers deciding a combination of mechincal and chemical weed control. In particular, their DCE explores farmers' preferences for cultivation strategies with and without glyphosate. Their main finding is that, once harvest of rapeseed is done, farmers have no clear preference for glyphosate when they implement a mulch seeding strategy. Their preference towards glyphosate is increased by presence and pressure of specific weeds. This evidence can be interpred as suggesting that phasing out of glyphosate need to be accompanied by training in non-chemical strategies to prevent weed infestation.

Chèze et al. (2020) highlight that despite reduction in use of pesticides being a major goal in developed countries, AES have not proven successful in promoting so. Via a DCE, they explore French farmers' willingness to reduce use of chemical pesticides. Following Danne et al. (2019)'s findings, their DCE includes risk of large production losses due to pests. Their findings indicate that this risk strongly limits farmers' willingness to change their practices, regardless of the consequences on average profit.

Blasch et al. (2022) have pointed out that precision farming technologies can support mitigation of environmental impacts from agriculture by reducing fertiliser use and irrigation while saving costs to farmers. As these technologies have not been widely adopted in Europe yet, they study farmers' willingness to adopt such technologies based on a DCE. They explore the role of social influence and show that knowledge of fellow farmers who have adopted the technology positively influences the valuation of precision farming technology features, a result that stresses the importance of social networks in the context of increasing the uptake of technologies that may support the achievement of Sustainable Development Goals.

Studies exploring stated preferences of farmers is Asia are available but not in the numbers that study European farmers. For instance, Bennett et al. (2018) implement a DCE to assess farmers' preferences for an AES targeting pesticide use by rural communities in and near the

Jiangsu-Yancheng Coastal Wetlands Rare Birds National Nature Reserve, China. The pesticide attribute is described in terms of annual reductions for usage in 2011. Their results suggest that each 1% reduction in pesticide application would require a compensation that falls in the range of 1.8 to 4.6 US dollars/ha.

Khan and Damalas (2015) present a contingent valuation protocol to cotton farmers in Punjab, Pakistan, to assess their willingness to pay (WTP) to avoid health risks associated with the use of pesticides. Around 23% of respondents reported a zero WTP, and the mean WTP of the 77% that reported non-zero WTP is around 5.8 US dollars on an annual basis.

Feil et al. (2015) is the only study analyzing preferences for collaborative arrangements via a DCE. A collaborative arrangement is a risk-sharing strategy that may occur in a multitude of institutional settings with different legal implications (Andersson et al., 2005). Arrangements may be *horizontal* (e.g. contracts among farmers) or *vertical* (e.g. contracts between farmers and processors). Examples of contract partners are farmers themselves, employees, processors, landlords, and government agencies (Larsén, 2008). The purpose of collaborative arrangements varies but what distinguishes these arrangements from other contracts is the intention to tackle obstacles imposed by economies of scale. For instance, Larsén (2010) and Lagerkvist and Hansson (2012) have documented that the efficiency of Swedish crop and livestock farms improves when farmers engage in machinery-sharing arrangements.

Feil et al. (2015) explore non-monetary factors that may deter the adoption of collaborative arrangements. Their DCE contains three attributes exploring the influence of features associated with the potential of conflict once a collaborative arrangement is in place. These attributes are the age of the potential collaborator, years of (positive) acquaintance with the potential collaborator, and production activities of the potential collaborator. These variables are meant to reflect like-mindedness and trust –as previous literature has documented that these are two features that farmers look for in potential collaborators (Artz et al., 2010; Larsén, 2007). Their estimated models allow them to conclude that farmers i) do prefer potential collaborate that are closer in age; ii) do prefer to initiate a collaborative arrangement with potential partners they have known for several years; and iii) do prefer to collaborate with partners with similar production activities.

Two instances of DCE studies analyzing collaboration attributes, but not in the context of the collaborative arrangements literature, are Villanueva et al. (2015) and Villanueva et al. (2017). Villanueva et al. (2015) assess Spanish olive grove farmers' willingness to participate in an AES collectively. The authors describe such collective participation as the joint enrollment of at least

5 growers with farms located in the same municipality. They find that it is unlikely that farmers participate collectively despite an incentive of up to 30% EU-wide bonus –an amount set in the EU Regulation to incentivize the collective participation. Villanueva et al. (2017) expand the results of Villanueva et al. (2015) by documenting heterogeneity in farmers' preferences across three olive grove subsystems –namely, mountainous rain-fed (MOG), plain rain-fed (ROG), and plain irrigated (IOG) olive groves. Keeping an identical description of collective participation, Villanueva et al. (2017) document a statistically significant higher willingness to accept (WTA) in ROG (224 US dollars/ha) than in IOG (133 US dollars/ha), with MOG lying between (175 US dollars/ha) – i.e. farmers demand compensation if collective participation is required.

Theoretical and empirical approaches

The Random Utility Model (RUM) provides theoretical support for the empirical analysis of DCE (McFadden, 1973, 1995; Train, 2003). The departure point of the RUM is that, when faced to J mutually exclusive alternatives, individual i chooses the alternative that provides him/her with the most utility. An individual's indirect utility from each alternative is denoted as U_{ij} for $i = 1,2, \dots, I$ and $j = 1,2, \dots, J$. The individual is assumed to know his/her own utility function with certainty. The researcher, however, cannot fully observe each U_{ij}. Thus, from the researcher's point of view and once a linear indirect utility function is assumed, U_{ij} is more appropriately expressed as

$$U_{ij} = V_{ij} + \varepsilon_{ij} \qquad V_{ij} = \beta' x_{ij} \tag{1}$$

where V_{ij} is the component observed by the researcher; x_{ij} is a $(M + 1) \times 1$ column vector denoting M alternative-specific attributes and the alternative-specific intercept; β is a $(M + 1) \times 1$ column coefficients vector representing the alternative-specific intercept, and the preferences for the alternative-specific attributes; and $\mathcal{E}_{ij}$ represents the purely random heterogeneity that the researcher is unable to observe.

If an individual chooses the alternative associated with the highest utility, then the individual i chooses, U_i^{max} where

$$U_i^{max} \equiv \max\{U_{i1}, U_{i2}, \dots, U_{iJ}\} \tag{2}$$

The willingness to pay for the alternative associated with the highest utility is expressed as the monetary value of the utility derived from U_i^{max}, i.e.

$$WTP_i \equiv \frac{U_i^{max}}{\beta_p} \tag{3}$$

where WTP_i is individual i's willingness to pay; and β_p is the price preference parameter. Under the assumption that indirect utility is linear in attributes, including income, β_p is the negative of the marginal utility from income.

However, under the assumptions embedded in equation [1], a researcher cannot observe as defined in equation [2]. He/she can only make statements in terms of expected utilities which are calculated over the error term ε_{ij}, i.e.

$$E(U_i^{max}) = E_\varepsilon\left[max\{V_{i1}, V_{i2}, \dots, V_{iJ}\}\right] \tag{4}$$

Under the assumption that $\mathcal{E}_{ij}$ is distributed according to a type I extreme value distribution, the expected maximum utility can be calculated through the logsum formula[4]

4 Pioneer derivations of the logsum formula were independently developed by Ben-Akiva (1972) and McFadden (1973).

$$E(U_i^{max}) = ln\sum_{j=1}^{J}\exp(V_{ij})$$

Accordingly, statements in terms of welfare measures can also only been made in expected terms. Given a before (b) and an after (a) situations, where after implies that a change in the available alternatives has occurred, the expected value of the compensation variation (CV) due to the change in individual i's utility is expressed as

(5)
$$E_\varepsilon(CV_i) = \frac{1}{-\beta_p}\left(E_\varepsilon(U_i^{max,a}) - E_\varepsilon(U_i^{max,b})\right) = \frac{1}{-\beta_p}\left(ln\sum_{j=1}^{J}exp(V_{ij}^a) - ln\sum_{j=1}^{J}exp(V_{ij}^b)\right)$$

The marginal willingness to pay (MWTP) can be derived from equation (5) as follows. Assume attribute q changes in a non-marginal fashion across all alternatives –i.e. $q^a = q^b + \Delta q$ is the level of q after Δq has been added to q^b. Introduce in equation (5) the change in q, and, because such a change occurs across all alternatives, factor it.[5] The expected CV can be expressed as follows

(6)
$$E_\varepsilon(CV_i[\Delta q]) = -\Delta q\frac{\beta_q}{\beta_p}$$

where β_q is the marginal utility from q. Equation (6) reduces to the willingness to pay for a marginal change across alternatives when $\Delta q = 1$, i.e. when the change in q is marginal, and

(7)
$$E_\varepsilon(MWTP_i) = -\frac{\beta_q}{\beta_p}$$

Equation (7) can be interpreted as the ratio of the marginal utility from the attribute that changes and the negative of the marginal utility from income.

Empirical estimations of the parameters required in the calculation of the expected marginal willingness to pay (i.e. $\hat{\beta}_q$ and $\hat{\beta}_p$) can be obtained via a conditional logit econometric specification. The departure point of this empirical model is the same as to establish the theoretical expectations of the welfare measures under discrete choice modeling, i.e. ε_{ij} is distributed according to a type I extreme value distribution. Under this assumption, the probability that individual *i* chooses alternative *j* is expressed as follows

(8)
$$P_{ij} = Pr[V_{ij} + \varepsilon_{ij} > V_{ik} + \varepsilon_{ik}\ \forall\ k \neq j] = Pr[\varepsilon_{ij} > V_{ik} - V_{ij} + \varepsilon_{ik}\ \forall\ k \neq j] = \frac{e^{V_{ij}}}{\sum_{k\in J} e^{V_{ik}}} = \frac{e^{\beta' x_{ij}}}{\sum_{k\in J} e^{\beta' x_{ik}}}$$

The conditional logit (CL) faces two limitations to model empirical discrete choice data (Train, 2003). First, the CL can represent systematic variation (i.e. taste variation that is related to observed characteristics) but not random taste variation (i.e. differences in tastes that cannot be linked to observed characteristics). Second, the estimation of the CL probabilities implies proportional substitution across alternatives –more flexible, more realistic patterns cannot be fitted with a CL model.[6]

The random parameter logit (RPL) results from adapting the CL model to incorporate non- systematic heterogeneity in preferences and discard the proportional substitution across alternatives. The RPL turns out to be a highly flexible model that can approximate any random utility model (McFadden and Train, 2000).

5 Further details can be found in Haab and McConnell (2002).

6 A third limitation, that is not relevant in the context of this paper, is that correlation over time is not captured by the conditional logit model (Train, 2003).

The RPL probabilities are the integrals of standard logit probabilities over a density of parameters. That is, keeping in mind equation (8), an RPL is a model whose choice probabilities can be expressed in the following form

$$P_{ij} = \int \frac{e^{\beta' x_{ij}}}{\sum_{k \in J} e^{\beta' x_{ik}}} f(\beta) d\beta \quad (9)$$

where $f(\beta)$ is a density function. Thus the RPL probability is a weighted average of the logit formula evaluated at different values of β, with the weights given by the density $f(\beta)$. In statistical terms, the weighted average of several functions is called a mixed function. Consequently, an RPL is a mixture of the logit function evaluated at different β's with $f(\beta)$ as the mixing function. Thus function can be discrete –with β taking a finite set of distinct values. Assume β takes C possible values –$b_1, b_2, \ldots, b_C$— with probability π_c that $\beta = b_c$. In this case, the RPL becomes a Latent Class Logit (LCL), and the choice probability is expressed as

$$P_{ij} = \sum_C \pi_c \left(\frac{e^{b_c' x_{ij}}}{\sum_J e^{b_c' x_{ik}}} \right) \quad (10)$$

In the context of an LCL specification, the expected value of the MWTP is estimated for each class:

$$E_\varepsilon \left(MWTP_{i,c} \right) = - \frac{\hat{b}_{q,c}}{\hat{b}_{p,c}} \quad (11)$$

Results from LCL specifications are useful to document heterogeneity in preferences because they yield vectors of preferences by class –i.e. $\hat{b}_c$. The researcher estimates as many LCL specifications as classes *believes* are worth trying, and a preferred LCL specification is chosen based on likelihood criteria that penalize the improvement in likelihood fit due to the increase in estimated parameters –Bayesian Information Criterion (BIC) and Akaike Information Criterion (AIC) are the usual suspects.

Methods and data

Farmers participating in our study have responded a questionnaire divided in four sections. The first section has captured farmers' demographic characteristics –e.g. marital status, education, age, and farming experience. The second section has gathered production data– e.g. production levels, crop prices. The third section gathers answers to our DCE. The fourth section has gathered farmers' socioeconomic characteristics and variables reflecting social cohesion of farmers' social network, and management of their market.

Discrete choice experiment

Via a discrete choice experiment (DCE), this paper explores whether farmers are interested in adopting chemical-free inputs and engaging in collaborative agreements. A DCE is a survey-based method requesting that farmers indicate their favorite alternative from among hypotethical scenarios described, in this application, in terms of three attributes. A DCE gathers stated preferences that reflect how respondents trade attributes, with particular attention to substitution rates between non-monetary attributes and a monetary attribute –the interested reader is referred to Johnston et al. (2017), who provide an introduction to DCEs; and to Train (2003), who provides a comprenhensive explanation of DCEs and the theory supporting them.

Table 1 describes attributes incorporated in our DCE. The first attribute refers to type of inputs used by farmers. On one hand, they may choose to use chemical-free fertilizers and pesticides; on the other hand, they may choose fertilizers that contain chemical ingredients —one of which is glyphosate. This attribute aims to explore whether farmers' preferences are aligned with

Mexican Federal government's goal of phasing out glyphosate.

The second attribute in our DCE describes collaborative arrangements. A collaborative arrangement is a risk-sharing strategy that decreases negative externalities from farming practices –granted negative externalities are positively correlated with input use (Andersson et al., 2005). A collaborative arrangement reduces transaction costs as it eases implemention of collective contracts between farmers and government or non-government agencies (Uthes and Matzdorf, 2013). A collaborative agreement may occur in a number of institutional settings with different legal implications (Andersson et al., 2005).

We explore farmers' preferences for two specific collaborative arrangements. The first arrangement is described as the possibility that the municipal government provides management support to farmers. The second arrangement is described as an insurance scheme shared by farmers. Our interest in these specific collaborative arrangements stems from their potential to tackle economics of scale in the Mexican context –keep in mind that 54% of agricultural units are smaller than five hectares (INEGI, 2019).

The third attribute in our DCE is a monetary attribute that is described as a percentage change in price of the crop that represents the majority of a farmer's net revenues. Inclusion of this attribute in a DCE enables practitioners to translate decisions reported by farmers into monetary values by taking advantage of the implicit rate of substitution between non- monetary attributes and money –as expressed in equation (7) in section 3.

Every respondent was faced to nine choice cards describing two hypothetical scenarios, one of which they were instructed to select based on their preferences. **Figure 1** illustrates a choice card.

Pilot version of the DCE were implemented to 20 farmers in Arteaga-Saltillo, Coahuila, Mexico –near university's campus of authors of this paper. These farmers use chemical inputs. Wording was modified based on feedback received from paritipants in pilot implementations.

Collection

Data collection took place between September and October, 2017. All Respondents to our DCE use chemical inputs –i.e. pesticides, fertilizers, or herbicides –, and were approached in small markets (*tianguis*) located in Central Mexico. These markets were chosen based on their proximity to *organic* markets –i.e. markets where traded products have been produced under a chemical-free regime. This recruitment strategy aimed to identify respondents that, while using chemical inputs themselves, are also aware of farming practices that rely on chemical-free inputs. This recruitment strategy has been followed so that we address the recommendation of making sure that respondents of DCEs relate to the market that is under simulation (Johnston et al., 2017).

Figure 2 illustrates the locations of the markets wherepotentional respondents were approached. Respondents in markets located in Texcoco, Estado de Mexico, are near to Tianguis Organico de Chapingo (Chapingo's Organic Market); respondents in markets located in Puebla are near to Tianguis Alternativo de Puebla (Puebla's Alternative Market); and respondents in markets located in Queretaro are near to Tianguis Buen Vivir (Good Living Market).

Descriptive statistics

Table 2 reports descriptive statistics of sample of small-scale farmers responding our DCE (N=146). The average producer is 50 years old, with 24 years of farming experience. Around 60% of respondents are married. In terms of variables reflecting social cohesion, 47% of respondents invite colleagues to home at least three times per year; 44% of respondents share machinery and tools; 50% has bartered in the market; and 44% have lent money to the people in his community.

Respondents sell mostly fresh products in a wide variety of vegetables and fruits, including dairy, bread, and processed products such as jams and hot sauces. Around 91% report net revenues between MXP 3,000 and MXP 10,000 on a monthly basis (i.e. between USD 150 and USD 500). Around 72% of respondents report having a job different from farming, and 47% report receiving governmental subsidies.

Empirical results

We have estimated latent class logit specifications to document heterogeneity in preferenes. **Table 3** reports likelihood criteria –AIC and BIC— of four specifications that assume, respectively, 2, 3, 4 and 5 classes. Both AIC and BIC suggest that the best fit is provided by the two-class specification. Consequently, the rest of this section refers to this two-class specification.

Table 4 reports coefficients from our preferred two-class latent class logit model. This model is composed of two equations –choice equation and membership equation. The choice equation has been informed with attributes of our DCE. The membership equation has been informed with respondents' characteristics –such as gender, education, and years of farming practice— and social cohesion variables –such as number of times that respondent invites colleagues from the market to his/her house.

Magnitude of coefficients reported in **Table 4** is not interepretable but their signs illustrate the direction of the effects on probabilities of selecting an hypothetical alternative –in the case of the choice equation— and the probability of belonging to a class –in the case of the membership equation.

According to **Table 4**, focusing on coefficients of the choice equation, we see that farmers belonging to class 1 represent around 60% of the sample. The negative sign associated with chemical-free inputs implies that farmers class 1 are unwilling to transition to a chemical- free regime. Similarly, the positive sign associated with offering management support from municipal government implies that farmers in class 1 are interested in receiving such a support. The negative sign associated with shared insurance scheme implies that farmers in class 1 are not interested in such an insurance scheme. Farmers in this class react negatively to a reduction in prices but do not react to an increase in the price of their main product.

In contrast, following an identical interpretation as above, farmers in class 2 are interested in the transition to a chemical-free regime, uninterested in receiving support from the government, and are interested in the insurance scheme. Also in contrast to class 1, farmers in class 2 are responsive to increases in price but not responsive to decreases in the price of their main product. These group of farmers represent around 40% of the sample.

According to **Table 4**, focusing on coefficients of the membership equation, we see that farmers with more farming experience, and with at least high school education, are less likely to belong to class 1. Similarly, farmers with networks with more social cohesion are less likely to belong to class 1. Gender and participation in other economic activity besides the farmers market are not statistically significant in the membership equation.

Discussion and conclusions

We have documented small-scale Mexican farmers' heterogeneity concerning their willingness to engage in collaborative arrangements and transition to a chemical-free regime by estimating latent class logit specifications on data gathered via a latent class logit specification.

Our preferred two-class logit specification yields a group of farmers that represents 60% of the sample, and i) report interest in receiving management support from municipal goverment; ii) are not interested in a shared insurance; and iii) are not willing to transition to a chemical-free input regime. On the opposite side of the preferences, the second group is i) willing to adopt chemical-free inputs, ii) uninterested on management support from municipal government; and iii) willing to acquire a shared insurance. The relative size of the group that is not interested in the chemical-free inputs is in line with previous DCE literature documenting farmers' predisposition against chemical-free inputs (Jaeck and Lifran, 2014; Khan and Damalas, 2015).

In addition to documenting interest in chemical-free inputs and willingness to engage in collaborative arrangements, this paper documents individual and social characteristics associated with the probability of belonging to the group of farmers that is willing to adopt chemical-free inputs and interested in participating in a shared insurance. This membership equation has been informed with variables reflecting respondents' farming experience, respondemts' education, and social cohesion of respondents' network. Membership equation's estimated parameters suggest that farming experience, education, and social cohesion are associated with a higher probability of belonging to the group of farmers that is willing to adopt chemical-free inputs and participate in a shared insurance. This characterization is consistent with previous literature documenting that social capital is associated with the establishment of collaborative arrangements (Asai et al., 2014).

Thus, findings in this paper suggest the presence of two types of preferences among small- scales farmers in our sample. On the one hand, some farmers are particularly unwilling to participate in collaborative agreements and to transition to a chemical-free regime. On the other hand, other farmers are interested in both, the transition and the collaborative agreements. Importantly, farmers with more education, more experienced, and more social capital are those who more likely belong to the class that prefers the transition and the collaborative arrangements. Also importantly, most of the farmers in our sample (60%) are not willing to transition to a chemical-free production regimen.

In the context of the current Federal government's goal of phasing out the use of glyphosate, findings in this paper are both good and bad news. On one hand, the good news is that around 40% of our respondents are willing to adopt chemical-free inputs –as long as the market compensates such transition via an increase in crop prices. On the other hand, the bad news is that most of our respondents are not interested in chemical-free inputs. However, this is not such a bad news because this same group of farmers reports interest in receiving management support from municipal government. We have motivated the inclusion of collaborative arrangements in our discrete choice experiment on the basis that collaborative arrangements' intention is tackling obstacles imposed by economies of scale. In particular, management support from the municipality is an arrangement that opens the door to negotiate changes to decrease negative externalities from farming practices at lower transaction costs.

Thus findings from this study allow us to suggest that with 40% of small-scale farmers willing to adopt chemical-free inputs, the Federal government may need to implement a slower strategy with the other 60% as they are interested in receiving management support.

Once management support is in place, and trust is gained, doors may open for a transition to chemical-free production regimes.

Our conclusions come with a limitation. We cannot claim that our sample is representative of preferences of small-scale farmers at the national level. We have implemented a recruitment strategy that increases the chances that our respondents, while using chemical inputs, are aware of farming practices using chemical-free inputs. This sample likely is not representative of famers at the national level. Further studies are required to corroborate and generalize findings reported in this paper.

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Figure 1.
Example of choice cards

	Opción A	Opción B
Usar **Plaguicidas y Fertilizantes Químicos**	NO Usar 	SÍ Usar 
Practicar una **Administración** del mercado con...	**Municipio**	**Municipio + Locatarios**
Cooperar ($) para formar un **SEGURO** de ayuda en casos de Emergencias Económicas	**NO Cooperar** 	**SÍ Cooperar** 
Cambiar el **Precio** de su producto principal	**-10%**	**-10%**
	A ☐	B ☐

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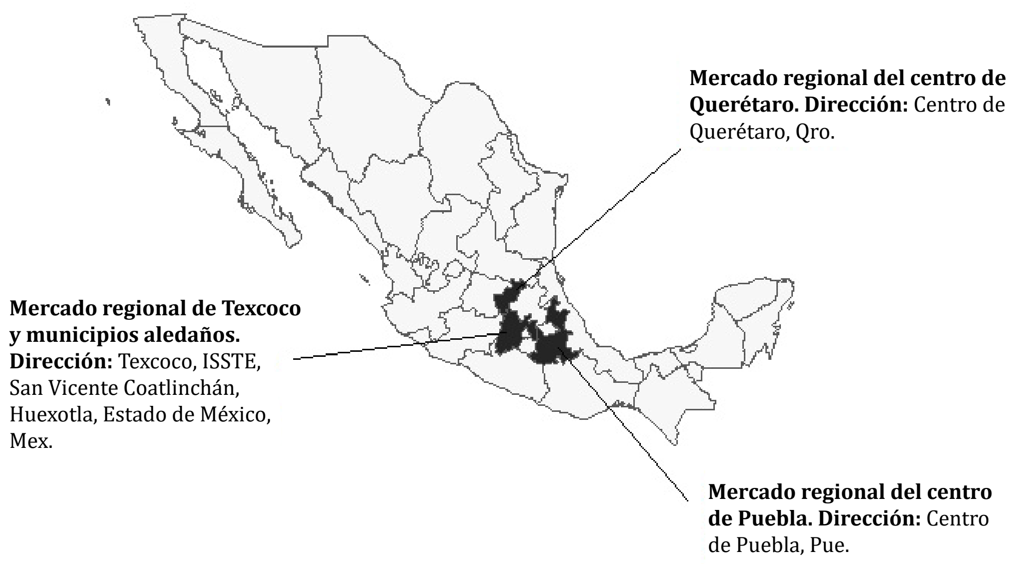
Figure 2.
Location of markets where respondets to our discrete choice experiment trade their products



Source: Own elaboration based on visited markets, using the R software (2020).

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Table 1.
Attributes and levels presented in discrete choice experiment

Description of attributwe	Levels
Type of inputs	
Use of chemical pesticides and chemical fertilizers	No use
	Use
Collaborative arrangements	
Management of market	Municipality management
	Farmers Management + municipality support
Adoption of an insurance scheme shared by all farmers	Yes
	No
Price change of crop that represents the majority of a farmer's net revenues	Increase: 30%
	No change
	Reduction: 10%

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Table 2.
Descriptive statistics of sample of small-scale farmers responding our DCE (n=146)

Variables	Mean	Std.Dev.	Max	Min
Age	49.7	7.9	65	38
Farming experience	24.5	8.7	40	5
Binary variables	% of 1: yes			
When lending money, ask for promissory notes	46.8	0.50		
Contributes to solve problems of the Tianguis	56.3	0.50		
Contributes to solve community problems	71.8	0.46		
Has raised funds with a social cause	84.3	0.36		
Has asked for government help?	56.3	0.50		
Do e xist sanctions/punishments in his market?	90.6	0.29		
Are the sanctions in the market crystal clear?	75.0	0.43		
Do you have another job?	71.9	0.45		
Do you receive government support?	46.8	0.50		
Counts: Percentages	Count 1	Count 2	Count 3	Count 4
Marital status	18.8	59.4	0.0	9.4
Studies	15.6	25.0	37.5	21.8
Inviting colleagues to home (Frequency: 1, 2, 3)	31.3	46.8	21.8	
Sharing machinery and tools (Frequency: 1, 2, 3)	37.5	43.7	18.7	
Bartering in the market (Frequency: 1, 2, 3)	34.3	50.0	15.6	
Lending money to colleages (Frequency: 1, 2, 3)	34.4	43.7	21.8	

Notes: Counts: Marital status: 1 = Single; 2 = Married; 3 = Co-habitation; 4 = Widow; 5 = Divorced Studies: 1 = Primary; 2 = Secondary; 3 = High school; 4 = Bachelor; 5 = Postgraduate

Frecuencies: **1** = 0 to 2; **2** = 3 to 5; **3** = >5

Table 3.
BIC and AIC of latent class specifications

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Number of classes	BIC	AIC
2	***211.77***	***190.45***
3	304.73	268.76
4	314.01	263.38
5	261.39	196.11

Table 4.
Coefficients arising from two-class latent class logit model (n=146)

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Variable	Class 1	Class 2
Choice equation		
1 if chemical-free inputs (reference category: chemical inputs)	**-1.535*** (0.243)**	**8.631*** (1.332)**
1 if market management with support from municipal government (reference category: municipal management)	**1.473*** (0.196)**	**-15.918*** (2.304)**
1 if shared insurance scheme (reference category: no sahred insurance scheme)	**-0.881*** (0.333)**	**1.041** (0.544)**
1 if 30% increase in price of most important crop based on net revenues (reference category: no change)	0.254 (0.280)	**7.991** (1.164)**
1 if 10% increase in price of most important crop based on net revenues (reference category: no change)	**-6.508*** (1.011)**	-78.185 (74.320)
Membership equation (class 2 is assumed reference category)		
Respondents' characteristics		
1 if female	0.283 (0.656)	N.A.
1 if highschool or college education	**-1.772** (0.945)**	N.A.
Numer of years with farming experience	**-0.130*** (0.042)**	N.A.

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Table 4.
Coefficients arising from two-class latent class logit model (n=146)

Variable	Class 1	Class 2
Social cohesion variables		
Times respondent invites colleagues from the market to his/her home	**-2.097*** (0.781)**	N.A.
1 if another job in addition to farming	-1.192 (0.736)	N.A.
Intercept	5.187 (1.572)	N.A.
Class share	0.601	0.399

Note: *, ** and *** indicate statistical significance at the 90%, 95% and 99% levels, respectively.