Explaining Mexican Farmers' Adoption of Hybrid Maize Seed - The Role of Social Psychology, Risk and Ambiguity Aversion

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We study the process of farmer decision making, particularly the choice of productivity enhancing hybrid seed, of smallholder maize farmers in southern Mexico. Few studies regarding small-scale farming in developing countries have factored in social psychology together with economic dimensions in that context. While acknowledging the importance of risk preferences, there is still a lack of consensus on how these preferences influence the process of technology choice. We combine subjective beliefs derived from the Theory of Planned Behavior, with experimentally elicited risk and ambiguity preferences to predict the degree of farmers' hybrid maize adoption in the coming season. Our results suggest that the higher farmers score on factors describing attitudes and subjective norms towards the use of hybrid seed, the higher is the degree of adoption. Farmers who are very risk averse score higher on attitudes towards the outcomes related to using hybrid seed, but intend to cultivate a smaller share of land with it. Ambiguity aversion is not significantly related to attitudes towards or the intended degree of adoption.

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Keywords: risk aversion; ambiguity aversion; hybrid maize adoption; theory of planned behavior; decision making; Mexico

1. Introduction

Maize is the main staple crop in Mexico and enjoys particular importance because of its role within the country's cultural history. The maize sector is characterised by a large number of smallholder rain-fed producers and a smaller number of more productive commercial producers farming irrigated land (Eakin et al. 2014). Commercial largely irrigated agriculture is in the Northwest, Northeast, and Center-west of Mexico while rain-fed farmers predominate in the central and southern regions (Sweeney et al 2013). The non-irrigated sector constitutes the largest share of Mexican maize production and has more variation in output because of its exposure to climate-induced crop failure (Eakin et al. 2014). Smallholders with 3 ha or less and whom produce almost exclusively on non-irrigated land, provide around 20% of nationally produced maize (Appendini 2014).

Over the last 30 years, there have been increasing yields in the commercial maize growing areas and increases in area planted and output, i.e. production rather than productivity, in the rain-fed areas. Productivity in the latter has remained at a stable low of around 1.5 tons per ha (Sweeney et al. 2013). Improving smallholders' productivity is of vital policy interest in order to ensure food security and self-sufficiency (UNCTAD 2013; SAGARPA 2013). Yield increases will require a substantial shift to greater use of improved maize varieties such as hybrids. This explains government and seed companies' interest in identifying the transition farmers i.e. those best placed to shift production from local to improved maize varieties, and the different obstacles to adoption.

Improved maize varieties, especially hybrids, have contributed to increased agricultural productivity, farm household welfare and poverty reduction in Mexico (Becerril and Abdulai 2010; Hellin et al. 2014). Although improved maize varieties have been available in Mexico for more than 40 years now, farmer adoption has been relatively low. There have been many government programs throughout Mexico to disseminate improved maize seed. The majority of rain-fed smallholder maize farmers, however, continue to use local maize varieties (Barkin 2002; Bellon et al. 2011) or grow traditional and hybrid maize at the same time (Bellon and Hellin 2011). Changes in varietal richness per farm are primarily the result of farmers' decisions (Dyer et al. 2014).

Economic studies have linked the reluctance of farmers to engage in particular productivity enhancing investments or practices to their risk aversion (Knight et al. 2003; Simtowe 2006; Hill 2009; Liu and Huang 2013; Liu 2013; Verschoor et al. 2016) and ambiguity aversion (Engle-Warnick et al. 2011; Ross et al. 2012; Barham et al. 2014). Risk refers to any situation in which possible future outcome events are not known with certainty, but only their probability distributions (Chavas 2004). Risk aversion refers to the disutility generated by this situation, relative to a situation without risk. A risk-averse decision maker then would be willing to pay a positive amount of money to eliminate risk. Independently of risk aversion, ambiguity aversion quantifies the relative disutility generated by subjective beliefs about probability distributions of payouts, as compared to the uncertainty generated by risky outcomes with objective payout probabilities (Klibanoff et al. 2005). With new technologies such as improved seeds, the probability distribution is ex-ante generally unknown to the farmer and therefore ambiguous. While the literature relating risk and ambiguity aversion to technology adoption is growing, there remains a lack of studies examining how exactly risk and risk aversion influence the process of technological adoption (Foster and Rosenzweig 2010). This is because to date relatively few studies regarding small-scale farmers' decision-making have factored in social psychology. Existing adoption studies often fail to take into account the full range of influencing factors (sociologic, economic and psychological) and, therefore, are seldom able to predict which factors have the greatest influence (Adesina 1995; Edwards-Jones 2006; Ajzen 2011; Martínez-García et al. 2013). A large number of adoption studies has been conducted but their contribution to towards improving extension and R&D has been limited because they do not sufficiently accommodate farmers' perceptions (Llewellyn et al. 2006; Wauters and Mathijs 2013).

In this paper, we investigate the subjective factors and preferences that drive Mexican farmers' decision to cultivate hybrid maize. We draw on social psychology, namely the theory of planned behavior (TPB) (Ajzen 1991), combining it with experimentally-elicited risk and ambiguity aversion parameters. According to the TPB, human behavior is a consequence of three psychological constructs: behavioral attitude, subjective norm, and perceived behavioral control towards the behavior. In our case, the behaviour of interest is the share of total maize area that a surveyed farmer intends to plant with hybrid maize in the coming season. To our knowledge, there has been to date only one paper that uses TPB to analyse farmer adoption of improved seeds in the context of a developing country (Yamano et al. 2015).

We suggest that there are two ways in which unspecific risk and ambiguity aversion, elicited in lottery choice games, can affect behavior within the TPB framework: Firstly indirectly, in terms of general attitudes affecting outcome, control, and normative beliefs towards a specific behavior as background factors. Secondly, directly as non-volitional control factors that affect the decision independently of attitudes, perceived control, or subjective norms regarding the behavior in question. This is the first paper to combine the TPB framework with experimentally elicited risk and ambiguity parameters and thereby gives insights into the roles of risk and ambiguity attitudes within the psychological process that guides decisions on hybrid seed adoption.

2. Conceptual Framework

2.1. The Attitude-Behavior Relationship

In social psychology, analysing the nexus of attitudes and behaviour has been a major field of research (Eagly and Chaiken 1993). In the psychological literature, attitudes are defined as "tendencies to evaluate objects favourably or unfavourably" and can be "directed towards any identifiable object" (Millon et al. 2003, p. 299). They are always subjective and reflect how a person views a certain object, not how it actually is. The assumption is that attitudes are connected to thoughts, feelings, and actions. Within the expectancy-value framework of attitudes (Ajzen and Fishbein 1975), an attitude is formed by all evaluative beliefs towards the respective attitude object. Attitudes within this framework can be measured by eliciting evaluative beliefs towards a range of potential attributes of the object in question (or, in the case of behaviour, potential outcomes). The functions of attitudes rely on the assumption that individuals behave consistently with them, meaning that attitudes influence behaviour.

The most important conceptual framework that connects attitudes and behaviour is the Theory of Reasoned Action (TRA) (Ajzen and Fishbein 1975). Within this framework, the authors distinguish attitudes toward objects and attitudes towards behaviours. The first category reflects general attitudes that influence a class of behaviours related to the object, while the latter reflect specific attitudes that influence the particular behaviour in question. Many studies attempt to predict specific behaviours with general attitudes which leads to poor predictive power (e.g. Fishbein and Ajzen 1974; Weigel and Newman 1976; Epstein 1979)

In behavioural decision theory, as opposed to social psychology, what is known as risk preferences corresponds to attitudes towards a risky option within the TPB framework (Weber et al. 2002) Theoretical evidence within the expected utility theory (EUT) suggests that farmers' risk attitudes influence production decisions (Feder 1980; Just and Zilberman 1983). Similar considerations hold for ambiguity attitudes (Engle-Warnick et al. 2011; Barham et al. 2014). Whether a risk or ambiguity averse farmer is less or more likely to adopt a specific input should then depend on whether it is increasing or decreasing yield risk (Just and Pope 1979) or ambiguity, respectively. Within behavioural decision theory, it is assumed that behavioural intentions, and consequently, behaviour, i.e. choosing a risky option, are only determined by one's preference for the risky option (Weber et al. 2002). However, attitudes can only serve to predict behaviour if it is volitional, i.e. individuals are free to perform it. When there exist non-volitional limitations, such as social norms or a lack of control over the behaviour in question, attitudes may not be able to determine the behaviour.

The insight that social norms and control beliefs, regarding the particular behavior, are relevant in addition to attitudes, lead to the extension of the TRA to the Theory of Planned Behavior (TPB) (Ajzen 1985, 1991). According to the TPB, the intention to engage in certain behaviour precedes the actual performance of that behaviour. This intention is, in turn, a function of the mentioned three latent psychological constructs: attitudes (ATT), subjective norms (SN) and perceived behavioural control (PBC), as shown in Table 1. These constructs consist of subjective beliefs regarding the behaviour in question. Importantly, within the TPB, the source of beliefs, and whether they are accurate, is irrelevant. This makes the assumptions of this model less cognitively demanding than many other economic rational choice models.

An attitude is formed by outcome beliefs, i.e. beliefs about consequences of the respective behavior involving the advantages and disadvantages of engaging in it. Subjective norms result from normative beliefs, i.e. perceived normative expectations of others, and perceived behavioral control results from control beliefs, i.e. whether one believes to have volitional control over several facets of the behavioral performance. The latter is related to concepts of self-efficacy and implies that people are able to act upon their intentions to the extent that they have the information, skills, abilities and other internal factors required to perform the behavior under investigation.[1] Actual control, such as skills and environmental factors, are assumed to influence

[1] Ajzen (1991) suggests to further weight beliefs: by outcome evaluations in the case of outcome beliefs, motivation to comply in the case of normative beliefs, and control belief power in the case of control beliefs. We neglected these weights to make the survey less demanding for our participants.

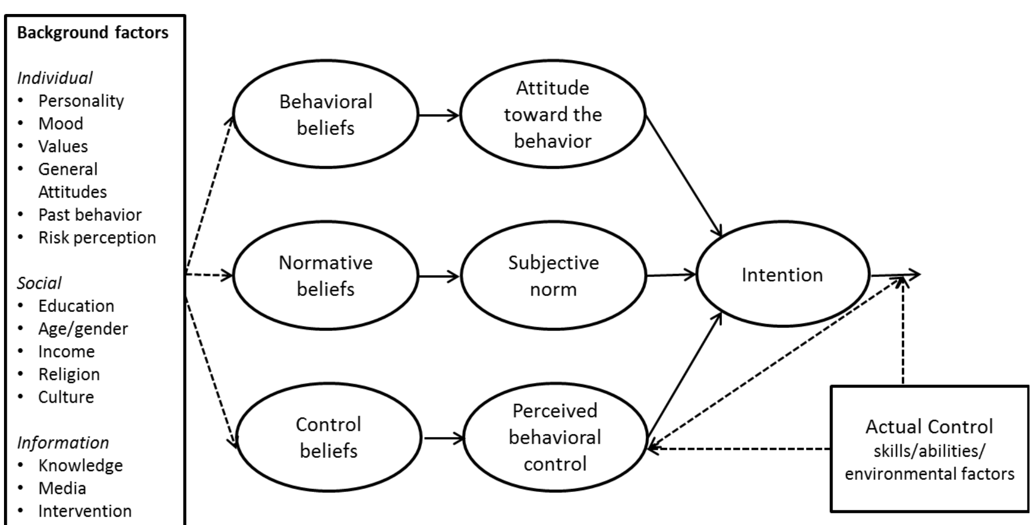
the performance of the behavior directly, however they are hard to determine empirically, which is why mostly subjective control beliefs are used as proxies for actual control. In an attempt to increase predictive power of the model, Fishbein and Ajzen (2011) suggest including past behaviour and habits as an additional predictor of behavioural intentions. The full TPB framework in its most recent form is depicted in Figure 1.

As can be seen in the left-hand box of Figure 1, all of the readily accessible beliefs regarding specific behaviours are thought to be influenced by background factors, which may involve, amongst others, general attitudes (Fishbein and Ajzen 2011). It is commonly criticized that background factors are mostly not explicitly included in TRA or TPB models, but just implicitly through their effects on behavioural, control, and normative beliefs (Beedell and Rehman 2000). Fishbein and Ajzen (2011) stress that whether a particular background factor affects beliefs is largely an empirical question and given the large amount of possible background factors the selection of these should be guided by theory.

Table 1: Drivers of behavior according to Ajzen (1991)

Outcome beliefs	Subjective probability of outcomes	**Attitude (ATT)**
Normative beliefs	Normative expectations and expectations of important referents	**Subjective Norm (SN)**
Control beliefs	Presence of factors that can facilitate or impede the behavior • Directly • Indirectly	**Perceived Behavioral Control (PBC)**

Figure 1: Framework of the Theory of Planned Behavior



Source: Fishbein and Ajzen (2011)

2.2. Risk and Ambiguity Attitudes

It is not clear how risk preferences based on behavioral decision theory might fit into the TPB framework. On the one hand, risk attitudes within EUT describe the degree of aversion towards risk over final wealth or utility, not the perceived riskiness of an option (Weber et al. 2002). Behavioral beliefs, i.e. outcome evaluations regarding the costs, benefits, and risks of a certain behavior that attitudes consist of according to the TPB correspond to perceptions about costs, benefits, and risks in terms of utility beyond the economic domain, within EUT (Lynne et al. 1995; Läpple and Kelley 2013). Within this framework, one could expect that individuals' perceptions about a new technology might be the same (in terms of the perceived costs, benefits, and risks), while the expected utility of adoption could still vary across individuals based on their differing degrees of risk aversion. This would mean that risk preferences influence the adoption decision directly and not via attitudes (i.e. perceived benefits, costs, and risks) towards adoption. Within the TPB framework, risk preferences could therefore be interpreted as non-volitional limitations towards the adoption behavior of the farmers, which would put them in the category of actual control factors.

On the other hand, risk and ambiguity attitudes, especially when they are not specific to the behavior that is being analyzed with them, could also be considered as general attitudes serving as background factors in influencing behavioral, control, and normative beliefs (Borges et al. 2015). For instance, more risk averse farmers might assess the potential outcomes in terms of benefits, costs, and risks of adopting hybrid seed less favorably than farmers who are less risk averse. More risk averse farmers have, for example, been found to perceive higher probabilities of future farm losses occurring (Menapace et al. 2013). Also, they may evaluate their personal control over adoption less favorably, since control beliefs are related to concepts of self-efficacy, which is positively related to risk-taking (e.g. Krueger and Dickson 1994). Furthermore, subjective norms, i.e. the degree to which one believes that relevant others have a stake in one's behavior, could be different for risk averse individuals, too. All this would result in systematically different scores on attitude, subjective norm, and perceived behavioral control constructs for individuals with higher degrees of risk aversion. Similar considerations would hold for ambiguity aversion as an additional parameter in the decision maker's utility function. We therefore propose a framework considering both potential functions of risk and ambiguity preferences, as depicted in Figure 2. This allows for an analysis of both direct and indirect associations with the degree of hybrid maize adoption.

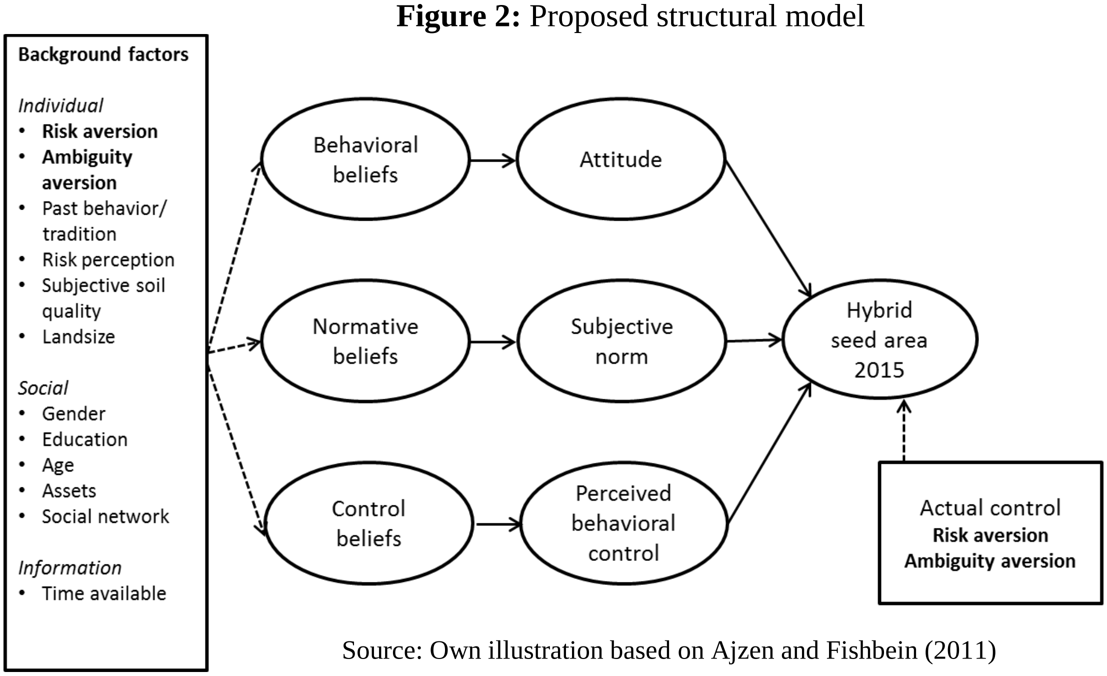
In order to obtain individual measures of risk and ambiguity aversion, we follow the approach by Barham et al. (2014), who define the degree of ambiguity aversion as uncertainty aversion minus risk aversion. Uncertainty aversion hence is the sum of risk aversion, i.e. the degree of disutility generated from probabilities over outcomes instead of certain outcomes, and ambiguity aversion, i.e. the disutility generated by uncertainty over the probabilities of outcomes. Subjects are assumed to be expected utility maximizers with a power utility function

$$U(c)=\frac{1}{1-r}c^{1-r}, \quad (1)$$

where utility U is a function of a monetary payoff c and the constant relative risk aversion (CRRA) coefficient r. Barham et al. (2014) offer an approach to calculate r for both situations with known and unknown probabilities. Where in situation with known outcome probabilities r^{risk} would only reflect risk aversion, in situations where outcome probabilities are not objectively given, $r^{uncertainty}$ reflects uncertainty aversion, i.e. the sum of risk and ambiguity aversion. Ambiguity aversion θ is then calculated as:

$$\theta=r^{uncertainty}-r^{risk} \quad (2)$$

Figure 2: Proposed structural model



Source: Own illustration based on Ajzen and Fishbein (2011)

3. Literature Review and Hypothesis Generation

3.1. Theory of Planned Behavior

The TPB has been used in several studies to analyze farmer decision making and specifically, adoption behavior. For instance, Hansson et al. (2012) use it to explain diversification decisions of Swedish farmers, finding that attitudes and subjective norms were particularly strong predictors of diversification decisions. In a study explaining soil conservation adoption in Belgium, Wauters et al. (2013) extend the TPB to include both perceived control and difficulty of applying the behavior, to find that only attitudes significantly affected the intention to adopt different soil conservation mechanisms. Lynne at al. (1995) applied the TPB to the adoption of water saving technologies by US strawberry farmers, stressing the empirical importance of both actual and perceived behavioral control in explaining behavior. Sambodo and Nuthall (2010), looking at adoption of an improved paddy-prawn system in Indonesia, find that the TPB constructs significantly explained variation in the intention to adopt, while perceived behavioral control was the weakest factor.

Zeweld et al. (2017) use the TPB framework to explain intentions to adopt minimum tillage and row planting in Ethiopia. They find that for both behaviors analyzed, attitudes and subjective norms were associated with stronger intentions to adopt the behavior, while perceived control was not significant. Social capital and training were, furthermore, found to be important background factors in explaining variations in attitudes and normative beliefs. Fielding et al. (2008) extend the TPB framework by adding group norms and intergroup perceptions to study riparian zone management adoption in Australia, confirming that attitudes and perceived behavioral control significantly explained the intentions to adopt, while subjective norms did not. We are only aware of one prior study using the TPB framework to understand seed adoption in a developing country. Yamano et al. (2015) find that farmers in India having received trial kits of Swarna-Sub1 rice seed tended to score higher on all three estimated TPB constructs regarding new technologies in general, while the authors report heterogeneous regional, caste and gender effects. Given this scarce prior evidence, we address a research gap by testing the following hypotheses:

H1: Behavioral attitudes towards hybrid seed use are positively correlated with farmers' intended adoption intensity.

H2: Subjective norms towards hybrid seed use are positively correlated with farmers' intended adoption intensity

H3: Perceived behavioral control towards hybrid seed use is positively correlated with farmers' intended adoption intensity.

3.2. Risk and Ambiguity Attitudes

Starting with the work of Binswanger et al (1980), most studies eliciting farmers' risk preferences have found that farmers are risk averse. The first attempts to analyze the effect of risk preferences on technology adoption consisted in eliciting farmers' subjectively perceived crop riskiness (O'Mara 1983; Smale et al. 1994); the use of risk preferences in that context is rather new. Arguing from the perspective of social psychology, one might criticize that risk attitudes are not specific to the behavior that is being studied with them when it comes to adoption decisions, so relating them directly to adoption behavior might lead to low predictive power. However, many studies find significant relationships between risk preferences and adoption.

Simtowe (2006) infers risk preferences from Malawian maize farmers' fertilizer choices, finding that hybrid seed adoption is lower for those who are more risk averse. Using a hypothetical question to elicit risk preference, Knight et al. (2003) find that risk averse Ethiopian farmers exhibit lower probabilities of adopting innovative inputs. Using a lottery choice task, Liu (2013) discover that Chinese cotton farmers who were more risk averse adopted bacillus thuringiensis (bt) resistant cotton seed later. Looking at the same sample of farmers, Liu and Huang (2013) find that more risk averse farmers use a greater quantity of pesticides.

Additionally, studies found that ambiguity aversion, another utility function parameter from behavioral decision theory, is also negatively correlated with adoption. Ambiguity characterizes situations where individuals are not able to assign unique probabilities to potential outcomes, but must form subjective beliefs over probability distributions. These subjective beliefs are not neutral, as proposed within subjective expected utility theory, but decrease the subjects' utility (Halevy 2007). There are to date only relatively few studies studying ambiguity aversion of farmers, with mixed results on whether farmers are generally ambiguity averse (Henrich and McElreath 2002; Akay et al. 2012).

From the perspective of a farmer faced with an adoption decision, a new seed variety may indeed appear ambiguous if he or she is not sure how the seed will respond to local weather conditions and must therefore form a subjective probability distribution over possible yield outcomes. Prior empirical evidence on this ground is mixed. Ross et al. (2010) find that ambiguity aversion decreased the probability and intensity of technology adoption, not risk aversion. However, results from Ward and Singh (2015) suggest that ambiguity averse farmers are not less likely to choose a new seed variety. Barham et al. (2014), in contrast, showed that US farmers with higher degrees of ambiguity aversion adopted genetically modified (GM) corn seed earlier; arguing that this is because the GM corn had a presumably ambiguity-reducing insect-tolerance trait. Engle-Warnick et al. (2011) find that more ambiguity averse farmers in Peru were less likely to diversify across seed types, which they argue to be an indicator for the propensity of farmers to try new varieties.

So far, risk and ambiguity preferences elicited in lotteries have not been applied in a TPB framework, either as background or actual control factors, potentially influencing a specific behavior. As stressed in the conceptual framework in section 2, there could be a direct or indirect association between the adoption behavior and risk and ambiguity aversion. The direct association would imply that for the same scores on behavioral attitude, subjective norm, and perceived behavioral control more risk and/or ambiguity averse subjects would still adopt a new technology less readily. The indirect association would imply that the outcome beliefs regarding economic and non-economic costs, benefits, and risks of adoption, are evaluated less favorably by farmers that are more risk and ambiguity averse.

To follow up on this existing evidence, we add to the literature by providing a framework that allows assessing simultaneously roles of subjective attitudes, norms and control perceptions regarding the degree of adoption of hybrid seed, as well as their interplay with risk and ambiguity attitudes. We propose a structural model slightly modified from Fishbein and Ajzen (2011), as depicted Figure 2, where we postulate that apart from a range of other individual, social and informational background factors, risk and ambiguity attitudes may influence behavioural beliefs, which make up the attitude towards hybrid seed use intensity. This leads us to the following hypotheses addressing this research gap:

H4: Risk aversion is negatively correlated with farmers' attitudes, subjective norms, and perceived behavioral control towards hybrid seed adoption.

H5: Ambiguity aversion is negatively correlated with farmers' attitudes, subjective norms, and perceived behavioral control towards hybrid seed adoption.

H6: Controlling for attitudes, subjective norms, and perceived behavioral control, risk aversion is negatively correlated with farmers' attitudes, subjective norms, and perceived behavioral control towards hybrid seed adoption.

H7: Controlling for attitudes, subjective norms, and perceived behavioral control, ambiguity aversion is negatively correlated with farmers' intended intensity of hybrid seed use.

4. Study Region

Maize holds a special status in Mexican agriculture as the crop's origins lay within the country (Hellin et al. 2014). Maize accounts for the highest percentage of agricultural land, is still a core part of the Mexican diet and remains a vital part of the rural economy (Eakin et al. 2014). The existence of a maize sector in Mexico is characterized by a large sector of poor, smallholder producers that have historically relied on labor-intensive production methods, and more productive commercial producers farming irrigated land. Around 60% of the national maize production comes from farms smaller than 10 hectares (Appendini 2014) which generally produce on rain fed land. However, their productivity is stagnating and thereby threatening food self-sufficiency (Sweeney et al. 2013).

Turrent et al. (2012) have estimated that maize yield gaps on rain-fed land are 43%, compared to just 10% on the country's larger irrigated farms. They posit that while Mexico currently imports 8-10 million tons of maize each year at a cost that reached $2.6 billion in 2011, it would be possible in the coming decade to increase annual production on land currently planted to maize from 23 to 33 million tons, meeting the current deficit of 10 million tons. In order to achieve this target, technologies that increase land productivity are desperately needed, and especially labor intensive ones such as chemical inputs and the increased use of improved varieties (Williams 2007). On average, currently only about 30% of the production units utilize improved seed varieties such as hybrids (INEGI 2014). Relative to the long time that hybrid maize has been already available in Mexico, adoption is still relatively low particularly in the poorer South of Mexico, where maize productivity is stagnating (Donnet et al. 2012; Ayala-Garay et al. 2013).

Our study area is the maize growing region of La Frailesca in the southern state of Chiapas, Mexico. Earlier research in La Frailesca suggests an ongoing transition of maize production over the last 10 years (Bellon and Hellin 2011). The region belongs to Mexico's pacific lowland tropics and forms part of a maize mega-environment with around 100,000 active small and medium scale farmers - an environment of "modernized smallholder agriculture" (van Heerwaarden et al. 2009). Nevertheless, 51.7% of the population live below the poverty line (CONEVAL 2010). Climatic risk was identified as most important source of vulnerability for the farmers (Bellon et al. 2006). While during the last years there has been an increase in the area devoted to hybrid maize varieties in La Frailesca, the number of farmers planting traditional varieties has hardly diminished i.e. farmers cultivate traditional and improved varieties simultaneously (Hellin and Bellon 2007; Bellon and Hellin 2011). Studies suggest that average maize yields in the southern state of Chiapas could reach up to 4.5 tons per hectare with hybrid seed as compared to the current average of 2.7 tons with local varieties (SAGARPA 2010).

Hybrid maize seed has been available in La Frailesca since the 1980s (Erenstein et al. 1998). This makes it an interesting place of study since an objective lack of access cannot be the primary factor accounting for non-adoption. Looking at an area where hybrid seed is widely available goes in line with Feder et al.'s (1985) definition of final adoption as "the degree of use of a new technology in long-run equilibrium when the farmer has full information about the new technology and its potential" (Feder et al. 1985). This makes our case study area especially worthwhile to investigate if the interplay of risk attitudes and subjective beliefs helps explaining the relatively low degree of hybrid maize adoption.

5. Data Collection

5.1. Sample Selection

A survey and incentivized lottery experiments to elicit risk and ambiguity aversion were conducted from April to July 2015 in La Frailesca. A total of 283 maize farmers were selected based on a stratified sampling procedure. First, 10 villages in the neighboring municipalities of Villaflores and Villa Corzo were selected purposefully with the support of a local university professor to cover a wide variability of degree of hybrid seed adoption. In the sampled villages, the sessions were announced publicly with help of the village head, and people could sign up to participate. The only criteria were being over 18, having basic numeric skills, and carrying the major responsibility for production decisions on the farms. Experiments and the subsequent individual survey were conducted in small groups of 5 to 15 people in the village assembly rooms. Five enumerators were always present. Dropping farmers from the sample who did not plan to grow maize in 2015 reduced the total number of farmers to 278. Furthermore, farmers with incomplete information in the survey or who could not answer selected questions had to be dropped. This further reduced the final sample used for the analysis to a total of 259 participants.

5.2. Experiment

The experiment to elicit risk and ambiguity preferences is based on Barham et al. (2014). We use two sets of lottery based lists each consisting of 11 decisions between a risky lottery and a certainty equivalent. As depicted in Table 2, in each lottery series participants had to choose 11 times between a constant save payout denoted as Option A and a lottery with decreasing expected payouts denoted as Option B. When choosing Option B participants could win a higher or lower payout depending on the color of a ball randomly drawn from an opaque bag (green for winning and orange for losing). For lottery series 1, the color distribution of the balls in the bag was unknown to the participants. They were just informed that in total there were 10 balls in the bag, and that there were winning (green) and losing (orange) balls, but not how many of each.

The payout of the losing draw in the lottery declines successively for each choice from being higher to lower than the respective save payout. This means that the expected value of the lottery option is decreasing successively in each of the 11 decisions. Monotonic switching was enforced by telling participants they could only switch once from choosing the lottery to choosing the save payout. The choices of not switching at all or switching in the first decision were explicitly presented to be possible options.[2] However, the number of winning or losing balls is not revealed in lottery series 1, so participants had to form a subjective winning probability $\hat{p}$. Another reason for subjects choosing differently when objective probabilities of outcomes are unknown apart from ambiguity aversion could be derived from subjective expected utility theory: subjects could

[2] Additionally to the example of never switching and switching in the first decision row, in each session we gave the examples of switching in decision row 6 and 10.

form different subjective winning probabilities $\hat{p}$.[3] However, since there is no reason to believe that drawing green is more likely than drawing orange, Laplace's principle of insufficient reason should hold and there should be no systematic deviation of one's subjective probability from $\hat{p}=0.5$. Therefore, this serves as our assumption for calculating ambiguity aversion, as done by Barham et al. (2014). In lottery series 2, participants again faced the same 11 decisions, but here the true winning probability of $p=0.5$ was revealed to the participants by showing them the content of the bag, revealing five green and five orange balls (Table 3).

The decision in second lottery with known probabilities serves to calculate individual risk attitudes. It is assumed that subjects are indifferent between the lottery option and the certainty equivalent in the switching round of the lottery, which allows solving for the CRRA coefficient *r*. For situations where probabilities are unknown, a similar parameter r is calculated assuming a subjective probability of $\hat{p}=0.5$, which reflects a measure of uncertainty aversion, i.e. a joint measure of risk and ambiguity aversion (Barham et al. 2014). Ambiguity aversion is then calculated as the difference of uncertainty aversion and risk aversion. If a participant is ambiguity neutral, she would choose to switch in the same round in both lottery series 1 and 2, as she would make no difference between the expected probability and the subjective probability $\hat{p}=p=0.5$. Then, the measure of ambiguity aversion would be equal to zero. If participants were ambiguity averse, they would switch at an earlier round in lottery series 1 (the ambiguous lottery) than in lottery series 2 (the unambiguous lottery). This behavior corresponds to an ambiguity aversion coefficient greater than zero. If participants were ambiguity seeking, they would switch at a later decision row in lottery series 1 than 2. This behavior would imply an ambiguity aversion coefficient smaller than zero.

Payouts were determined only after experiments and the concluding survey in order to avoid priming effects. One of the decisions in the lottery-based experiment was selected randomly for payment for all participants in one session. Those who chose the save payout in the selected round received the respective amount. Among those who opted for the lottery option B, one participant volunteered to draw from the bag containing five orange and five green balls. If green

[3] Ward and Singh (2015) also elicited subjective probabilities beforehand and used these in the calculations of ambiguity aversion. However, this did not cancel out ambiguity aversion, indicating that subjects had different ambiguity preferences and not only different subjective probabilities.

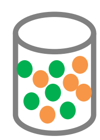
was drawn, all participants who had chosen the lottery option received the higher winning payout for the selected round. When orange was drawn, all participants received the lower payout. The resulting amount was converted in the relation 1:100 into cash, i.e. for every 1,000 in the experiments participants could earn $10 MXN (approx. $0.62 USD) [4] in cash. The average payout for the whole experiment was $170 MXN; almost double the daily wage of an agricultural laborer at the time of the survey. [5]

Table 2: Lottery-based experiment, Series 1

Decision	Option A	Option B: Green	Option B: Orange	CRRA
1	$1,000 MXN	$2,000 MXN	$1,000 MXN	∞
2	$1,000 MXN	$2,000 MXN	$800 MXN	3.76
3	$1,000 MXN	$2,000 MXN	$650 MXN	1.86
4	$1,000 MXN	$2,000 MXN	$500 MXN	1.00
5	$1,000 MXN	$2,000 MXN	$400 MXN	0.65
6	$1,000 MXN	$2,000 MXN	$350 MXN	0.52
7	$1,000 MXN	$2,000 MXN	$300 MXN	0.4
8	$1,000 MXN	$2,000 MXN	$250 MXN	0.31
9	$1,000 MXN	$2,000 MXN	$200 MXN	0.22
10	$1,000 MXN	$2,000 MXN	$100 MXN	0.09
11	$1,000 MXN	$2,000 MXN	$0 MXN	0.00

Source: Author's own illustration based on Barham et al. (2014)

Table 3: Decision sheet for Lottery Series 2



	Option A		Option B: Orange=5	Option B: Green=5	
12	$1,000		$2,000	$1,000	
13	$1,000		$2,000	$800	
14	$1,000		$2,000	$650	
15	$1,000		$2,000	$500	
16	$1,000		$2,000	$400	
17	$1,000		$2,000	$350	
18	$1,000		$2,000	$300	
19	$1,000		$2,000	$250	
20	$1,000		$2,000	$200	
21	$1,000		$2,000	$100	
22	$1,000		$2,000	$0	

[4] Exchange rate based on average over the time of the survey, May to July 2015. Source: fxtop.com.
[5] Another experiment followed the lottery games described here, which is however not part of this paper.

5.3. Survey

After completing the lottery-based experiment, participants were surveyed individually to obtain sociodemographic and production data, as well as a set of items on their subjective behavioral, normative, and control beliefs regarding hybrid seed, as well as their past experience and traditional importance of landrace seed. The dependent variable is the share of total maize area that the farmer planned to devote to hybrid maize cultivation in the coming growing season following our survey in spring 2015. While the aim was to capture intended behaviour, at the time of the survey (April to July), farmers had already largely purchased the seed, and because of local climatic variations, in some cases they had already planted it. That is why our dependent variable captures rather the actual intensity of hybrid seed use, than the farmers' intentions.

In order to elicit attitudes, control beliefs, and subjective norms, we first drew on the existing seed adoption literature. Studies have established that farmers favor certain attributes of seed varieties, such as early maturity, yield potential, stress and disease tolerance and processing quality (Joshi and Bauer 2006; Kalinda et al. 2014; Mehar et al. 2015). Further favorable attributes of maize elicited in our study region include higher yields, desired maturity and height, resistance against diseases and insects, as well as resistance to lodging (Bellon et al. 2006). Other factors that might inhibit adoption include trust in the local varieties and a fear of unexpected or variable performance of hybrids, as well as dependency on other complementary inputs (Arellano and Arriaga 2001). Farmers were also found to associate with landraces shorter growing cycles and better outcomes under suboptimal soil management conditions. The identified motivations of farmers' for the use of hybrid maize seed were experimental curiosity, economic considerations, yields and resistance to lodging (Pérez et al. 2002).

These attributes are stated as potential outcomes of hybrid seed adoption and reflect readily accessible beliefs. We derived a range of items from literature and complemented them in focus group interviews in the study region, leading to a total of 16 statements related to hybrid seed use (**Error! Reference source not found.**) and three regarding the tradition and habit of landrace cultivation (Table 5**:** Items and CFA loadings for "Tradition" construct

Statements	Mean	SD	Factor Loading	Cronbach's Alpha
Criollo maize has given me good harvests in the past.	3.99	1.43	**0.82**	0.70
Cultivating criollo maize is part of my tradition.	3.75	1.55	**0.85**	0.65
I have easy access to criollo maize in my village.	3.67	1.48	**0.59**	0.87

Observations	259

Significant loadings appear in bold.

). The items were stated in a similar way as in Yamano et al. (2015) and Hansson et al. (2012). Respondents were asked to evaluate these on a 5-point Likert scale.

5. Analysis and Results

5.1. Descriptive Statistics

Table 6 presents some descriptive statistics regarding the sociodemographic characteristics of our sampled farmers. The sample is predominantly male, containing only 9% women, which is not surprising since we only addressed agricultural decision makers, which is largely a male responsibility. The average farmer in our sample is 46.2 years old, lives in a household consisting of 4 persons, received 5.4 years of formal education, and has cultivated maize for 23.6 years. 64% of farmers cultivated some hybrid maize in 2014 and 68% planned to do so in 2015. On average, they did so on 58% of their total maize area in 2014 and planned to do so on 62% in 2015. Farmers reported the availability of hybrid maize to be 12.2 years, on average. Of our sample, 35% qualified as very risk averse and 36% as ambiguity averse according to the classification proposed in Barham et al. (2014). As a proxy for social network, we asked farmers to evaluate the following statement on a scale from 1 ("completely disagree") to 5 ("completely agree"): "Other farmers ask me for farming advice", where participants score on average 4.2. In order to assess farmers' perceived likelihood of incurring maize losses in the coming season, we asked them to evaluate the probability on a scale from 1 ("very unlikely") to 5 ("very likely"), where they scored 2.8 on average.

5.2. Factor Analysis

The behavioural, normative, and control beliefs regarding hybrid seed adoption according to the TPB (**Error! Reference source not found.** and Table 5**:** Items and CFA loadings for "Tradition" construct

Statements	Mean	SD	Factor Loading	Cronbach's Alpha
Criollo maize has given me good harvests in the past.	3.99	1.43	**0.82**	0.70
Cultivating criollo maize is part of my tradition.	3.75	1.55	**0.85**	0.65
I have easy access to criollo maize in my village.	3.67	1.48	**0.59**	0.87
Observations	259			

Significant loadings appear in bold.

) were used for confirmatory factor analysis (CFA). Several were dropped, however, due to non-significant or significant cross-loadings, resulting in the items, as indicated in **Error! Reference source not found.**. For our sample size, according to Hair et al. (2010), the minimum significant factor loadings required are 0.35. We recognize that the score on the normative belief statement "The maize buyers prefer hybrid maize" with 0.33 is below this threshold. However, when applying a measure of sampling adequacy (Kaiser-Meyer-Olkin measure), values above 0.5 for the entire matrix and each variable indicate appropriateness of the data for factor analysis, which is why we leave the variable in the analysis. We furthermore recognize that some item-to-item correlations for our three constructs (ranging from 0.11 to 0.41) and Cronbach's alpha (ranging from 0.34 to 0.58) are on the lower end of acceptable cut-off values, but given the strong theoretical and empirical evidence in the related literature for the proposed measurement model we regard it to be valid. We also estimate factor scores for the items listed in Table 5**:** Items and CFA loadings for "Tradition" construct

Statements	Mean	SD	Factor Loading	Cronbach's Alpha
Criollo maize has given me good harvests in the past.	3.99	1.43	**0.82**	0.70
Cultivating criollo maize is part of my tradition.	3.75	1.55	**0.85**	0.65
I have easy access to criollo maize in my village.	3.67	1.48	**0.59**	0.87
Observations	259			

Significant loadings appear in bold.

, which relate to habit, tradition, and satisfaction with regard to landrace maize cultivation. The resulting construct is termed "Tradition" (T). In Table 7, average scores on attitudes, social norms, perceived behavioral control, tradition, as well as risk and ambiguity aversion estimates are presented.

Table 4: Item scores and CFA loadings for attitude, behavioral control, and subjective norms

	Mean	SD	Loadings on construct
			Attitude (ATT)
Behavioral Beliefs			
B9 Hybrid maize has shorter growing cycles than criollo maize.	4.37	0.95	**.40**
B3 With hybrid maize seed I can obtain a much higher yield compared to criollo maize.	4.42	0.97	**.37**
B5 Hybrid maize is more tolerant to wind than criollo maize.	4.44	0.93	**.52**
B7 Hybrid maize is less well adapted to the local climate compared to criollo maize.	3.75	1.30	Excluded
B1 Hybrid maize can be sold at higher prices than criollo maize.	3.10	1.15	Excluded
B14 Hybrid maize is more resistant to putrescence than criollo maize.	3.41	1.60	Excluded
C1 For me it is easy to get the information I need before using a new seed variety for the first time.	4.10	1.16	Excluded
Control Beliefs			**Perceived Behavioral Control (PBC)**
C2 When I have problems in my production, I know where to get help.	3.36	1.54	**0.43**
C3 For me it is easy to get credit to buy seeds and other inputs.	2.73	1.45	**0.60**
C7 I have the necessary financial resources to buy hybrid seed.	2.73	1.49	**0.54**
C5 I consider my soil quality to be adequate for cultivating hybrid maize.	4.13	1.17	Excluded
C8 I consider the climatic preconditions in my area adequate for cultivating hybrid maize.	4.09	1.14	Excluded
Normative Beliefs			**Subjective Norms (SN)**
N1 My family prefers me to cultivate hybrid maize.	3.66	1.34	**0.45**
N3 The maize buyers prefer hybrid maize.	3.91	1.07	**0.33**
N4 The input providers recommend me to use hybrid seed.	4.61	0.73	Excluded
N2 The majority of other producers in my village use criollo maize.	3.19	1.60	Excluded
Observations	259		

Table 5: Items and CFA loadings for "Tradition" construct

Statements	Mean	SD	Factor Loading	Cronbach's Alpha
Criollo maize has given me good harvests in the past.	3.99	1.43	**0.82**	0.70
Cultivating criollo maize is part of my tradition.	3.75	1.55	**0.85**	0.65
I have easy access to criollo maize in my village.	3.67	1.48	**0.59**	0.87
Observations	259			

Significant loadings appear in bold.

By mean comparison, we find that adopters (including partial adopters) score significantly higher on attitude, social norms, and perceived behavioral control towards hybrid seed ($p \leq 0.01$) and perceived behavioral control ($p \leq 0.10$), and surprisingly also on the tradition variable ($p \leq 0.01$). The adopters, as would be expected, are also less risk and ambiguity averse ($p \leq 0.10$). These descriptive results are in line with findings from the literature and hint towards validity of our hypotheses.

5.3. Regression Analysis

To represent the structural form proposed by the TPB and be able to identify direct and indirect effects of risk preference, we propose a simultaneous equation model, which takes into account that our explanatory variables as in equations 3 to 6. We estimate this system of equations using three-stage least squares (Zellner and Theil 1962), assuming that error terms ε_i of equations 3 through 6 are correlated:

$$\mathrm{ATT} = \mathrm{c} + \beta_1 \mathrm{ra} + \beta_2 \mathrm{aa} + \beta^{'} \mathrm{X} + \varepsilon_1 \quad (3)$$

$$\mathrm{SN} = \mathrm{c} + \beta_1 \mathrm{ra} + \beta_2 \mathrm{aa} + \beta^{'} \mathrm{X} + \varepsilon_2 \quad (4)$$

$$\mathrm{PBC} = \mathrm{c} + \beta_1 \mathrm{ra} + \beta_2 \mathrm{aa} + \beta^{'} \mathrm{X} + \varepsilon_3 \quad (5)$$

$$\mathrm{Y} = \mathrm{c} + \beta_1 \mathrm{ra} + \beta_2 \mathrm{aa} + \mathrm{ATT} + \mathrm{SN} + \mathrm{PBC} + \varepsilon_4 \quad (6)$$

We use the standardized factor scores for our three constructs attitude (ATT), subjective norms (SN), and perceived behavioral control (PBC) as dependent variables and regress them on dummy variables ra and aa that we create as binary indicators for high risk aversion ($\mathrm{r} \geq 3.76$) and any ambiguity aversion ($\theta > 0$), respectively. Additionally, a vector X of explanatory variables that are commonly used in technology adoption studies is included in the regression: years of maize production experience and education of the farmer, self-reported years hybrid seed availability, land size, tradition/habit, subjective evaluation of the plot's soil quality, subjective probability of incurring maize losses in 2015, and a proxy for the farmer's social network. In a simultaneous regression, the share of maize area intended to be planted with hybrid maize in 2015, Y, is modelled as a function of ra, aa, ATT, PBC, and SN. Using this structural model we can distinguish the indirect effect of risk and ambiguity aversion as background factors, going through attitudes, subjective norms, or perceived behavioral control (equations 3, 4, 5), and the direct effect on the intensity of adoption decision (equation 6).

Table 6: Descriptive characteristics of sample

	Mean	SD
Producer age (years)	46.22	14.30
Education (years)	5.42	3.67
Household size	4.01	1.68
Female (dummy)	0.09	0.29
Asset count [a)]	5.87	1.50
Parents speak indigenous language (dummy)	0.04	0.20

Land size (ha)	7.87	9.40
Total maize area in 2014 (ha)	2.54	1.82
Evaluation of soil quality (from 1=very bad; to 4=very good)	2.59	0.63
Maize production (years)	23.63	16.23
Used hybrid seed in 2014 (dummy)	0.64	0.48
Used hybrid seed in 2015 (dummy)	0.69	0.46
Area hybrid maize 2014 (share of total maize area)	0.58	0.46
Area hybrid maize 2015 (share of total maize area)	0.62	0.44
Hybrid seed available (years)	12.20	7.25
Tradition [b)]	0.71	0.34
Perceived probability of maize loss in 2015 (from 1=very unlikely; to 5=very likely)	2.77	0.97
Social network proxy: "Other producers ask me for farming advice" (from 1=completely disagree; to 5= completely agree)	4.24	1.17
Risk aversion [c)]	1.64	1.54
Risk aversion (dummy) [d)]	0.32	0.47
Ambiguity aversion [e)]	-0.07	1.91
Ambiguity aversion (dummy) [f)]	0.36	0.48
Observations	259	

[a)] Household asset variables include dummies for ownership of: TV, concrete floor, fridge, cellphone, washing machine, microwave, running water, separate bathroom inside/outside, draft animals, tractor, de-graining machine, vehicle, and cattle.
[b)] Based on standardized factor loadings from Likert-scale evaluations of three items related to tradition and habit of criollo maize cultivation.
[c)] CRRA coefficient $0 \leq r \leq 3.67$.
[d)] 1 if r=3.76 (extremely risk averse), 0 otherwise.
[c)] Ambiguity aversion coefficient $0 \leq \theta \leq 3.67$.
[f)] 1 if $\theta > 0$ (ambiguity averse), 0 otherwise.

Table 7: Behavioral constructs, risk, and ambiguity attitudes by adoption status

	Mean Adopters[1]	Mean Non-Adopters	Mean Difference[2]
Attitude; ATT	0.692	0.833	-0.141***
			(-5.33)
Perceived behavioral control; PBC	0.456	0.514	-0.058*
			(-1.68)
Social norm; SN	0.479	0.586	-0.107***
			(-4.11)
Tradition; T	0.897	0.625	0.272***
			(6.46)
Risk Aversion; CRRA	1.526	1.889	0.362*
			(1.75)
Ambiguity Aversion	-0.242	0.207	0.450*
			(1.75)
Observations	180	79	259

Standardized factor scores. Standard errors in parenthesis.
[1]Adopter refers to farmers intending so use hybrid seed in 2015
[2]Significance stars are based on two-sided t-test. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

5.4. Regression Results

In Table 8, results from estimating equation 3 to 6 are reported. The intended degree of hybrid maize adoption in 2015 is significantly higher for those farmers who score higher on the behavioral attitude and subjective norm variables, while perceived behavioral control is insignificant. This suggests control beliefs regarding the use of hybrid seed are not crucial for the adoption decision in our context. This result is in line with prior results by Sambodo and Nuthall (2010), Wauters and Mathijs (2013), and Zeweld et al. (2017), who find no significant association of behavioral control and the respective adoption behavior studied. Therefore, we cannot reject hypotheses H1 and H2, but must reject our hypothesis H3.

Furthermore, results suggest that farmers' scores on attitudes towards hybrid seed are significantly more negative larger the farmers' land, the higher is the perceived probability of incurring a maize loss in the coming season, and the higher the score on the factor "Tradition". Attitudes are significantly more positive the larger the farmers' social network, the longer hybrid seed is available in the farmer's village, and for farmers belonging to the highest category with regards to risk aversion. The latter result shows that the very risk averse farmers actually score higher on attitudes towards hybrid seed, while ambiguity aversion is not significantly correlated with attitudes. This means we must reject both our hypothesis H4 and H5, that risk and ambiguity aversion are negatively correlated with attitudes towards hybrid seed cultivation. This result confirms the notion that very risk averse farmers evaluate the outcomes of hybrid seed adoption systematically more favorably than those with lower degrees of risk aversion. This could also be due to the fact that the outcome beliefs used in to construct the attitude factor also contains outcomes that decrease production risk, such as shorter growing cycles and wind tolerance. The very risk averse farmers may be more aware of those risk-reducing features of hybrid maize and perceive them more favorably.

Looking at the other constructs, subjective norms regarding hybrid seed are significantly lower the higher the farmer scores on the factor "Tradition", and the longer hybrid seed is available. Subjective norms are more positive the higher the education level of the farmer, the longer he has been producing maize, and the more assets he owns. Perceived behavioral control towards the use of hybrid seed cultivation is significantly lower for those farmers who perceive a higher probability of incurring a maize loss in 2015, and for those with larger land. Behavioral control is significantly higher for those who have more assets, while risk and ambiguity aversion are insignificant in explaining behavioral control.

Looking at the direct association between risk aversion and hybrid seed intensity, we find the expected negative relationship, wherefore we cannot reject hypothesis H6. The association of ambiguity aversion with intended adoption is insignificant, wherefore we must reject hypothesis

H7, that ambiguity aversion would be negatively associated with adoption intensity. This result suggests that even though farmers might have the same behavioral attitudes, subjective norms, and perceived control towards hybrid seed, nevertheless adopt less hybrid maize when they are very risk averse. This means the effect of risk aversion on behavior is not adequately captured by behavioral attitudes as defined within the TPB, but should be accounted for separately in analyzing decisions on the intensity of adoption.

6. Conclusion and Outlook

In Mexico, maize productivity is stagnating in many parts of the country, and especially so for smallholders in marginalized regions that produce on rain fed land. Improving their productivity is of vital policy interest in order to ensure food security and self-sufficiency. It is argued that yield increases will require a substantial shift to greater use of improved maize varieties such as hybrids, which have been reluctantly adopted despite their relatively long availability in Mexico. When explaining adoption behavior of farmers, a wide range of explanatory factors have been identified theoretically and empirically (Foster and Rosenzweig 2010).

It has been stressed by the literature that adoption studies need to accommodate farmers' subjective perceptions in order to offer meaningful conclusions (Llewellyn et al. 2006; Wauters and Mathijs 2013). Therefore, frameworks from social psychology, such as the Theory of Planned Behavior (Ajzen 1991), have started to be used in studying farmers' adoption behavior. At the same time, there is a growing strand of literature that relates risk and/or ambiguity attitudes to adoption behavior. In this paper, we argue that combining the Theory of Planned Behavior with experimentally elicited risk and ambiguity aversion parameters can shed light on how these parameters affect the decision process when it comes to the intensity of adoption. The results from lottery choice games and surveys conducted with a sample of Mexican farmers suggests that while risk aversion is indirectly positively associated with hybrid seed adoption via attitudes towards hybrid seed, it is directly negatively associated with adoption. Risk and ambiguity aversion are not related to subjective norms or control beliefs. Ambiguity aversion is neither directly nor indirectly associated with adoption at a common significance level.

These results confirm the notion that there are two ways in which unspecific risk aversion elicited in lottery choice tasks can affect behavior within a social-psychological decision framework, directly and indirectly. It was found that the very risk averse farmers evaluated the outcomes of using hybrid maize more favorably than the less risk averse farmers, while at the same time they adopt relatively less. This suggests that in the Mexican context, policy efforts in order to increase hybrid maize adoption could, on the one hand, aim at changing farmers' attitudes towards hybrid seed, i.e. by promoting or demonstrating favorable traits of the seeds. This, however, is not likely to radically change the degree of adoption of the very risk averse farmers, who do not use less hybrid seed because they evaluate the outcomes less favorably. On the contrary, they may even assess potential benefits, costs, and risks associated with hybrid maize cultivation more favorably, but still adopt less. Therefore, decreasing the actual financial risks of hybrid seed cultivation, either by lowering the cost of seed, help offering hybrid maize with more risk-decreasing traits, or providing safety nets or insurance for hybrid maize production seem to be more promising policy instruments to increase the adoption intensity.

Table 8: Results from three-stage least squares regression

	ATT	SN	PBC	Hybrid Maize Share 2015
ATT	-	-	-	0.95***
				(0.12)
SN	-	-	-	0.79***
				(0.12)
PBC	-	-	-	0.10
				(0.10)
Risk aversion; dummy [a)]	0.06**	0.01	-0.01	-0.16***
	(0.03)	(0.03)	(0.04)	(0.06)
Ambiguity aversion; dummy [b)]	-0.02	-0.01	-0.04	-0.06
	(0.03)	(0.03)	(0.04)	(0.06)
Maize production; years	0.00	0.00***	-0.00	-
	(0.00)	(0.00)	(0.00)	
Education; years	0.00	0.01**	-0.00	-
	(0.00)	(0.00)	(0.01)	
Asset index [c)]	0.04	0.21***	0.26**	-
	(0.08)	(0.08)	(0.10)	
Hybrid seed available; years	0.01***	-0.01***	0.00	-
	(0.00)	(0.00)	(0.00)	
Criollo tradition/habit [d)]	-0.11***	-0.10***	0.08	-
	(0.04)	(0.04)	(0.05)	
Maize loss probability 2015 [e)]	-0.03***	0.00	-0.04***	-
	(0.01)	(0.01)	(0.02)	
Evaluation of soil quality [f)]	0.01	-0.00	0.02	-
	(0.02)	(0.02)	(0.02)	
Social Network Proxy [g)]	0.03***	0.01	0.01	-
	(0.01)	(0.01)	(0.01)	
Land size; ha	-0.00**	-0.00	-0.00*	-
	(0.00)	(0.00)	(0.00)	
Constant	0.66***	0.50***	0.45***	-0.55***
	(0.09)	(0.09)	(0.13)	(0.13)
R^2	0.23	0.08	0.11	0.19
Observations		259		

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Standard errors in parenthesis.

[a)] 1 if r=3.76 (extremely risk averse), 0 otherwise.

[b)] 1 if θ>0 (ambiguity averse), 0 otherwise.

[c)] Based on principal component analysis of household assets, including dummies for ownership of TV, concrete floor, fridge, cellphone, washing machine, microwave, running water, separate bathroom inside/outside, draft animals, tractor, de-graining machine, vehicle, cattle.

[d)] Based on standardized factor loadings from Likert-scale evaluations of three items related to tradition and habit of criollo maize cultivation.

[e)] Based on evaluation of farmers perceived probability of incurring a maize loss in 2015, from 1=very unlikely to 5=very likely.

[f)] Based on subjective evaluation of the plot's soil quality from 1=very bad to 4=very good.

[g)] Evaluation of statement: "Other producers ask me for farming advice" from 1=completely disagree to 5= completely agree.

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