TO ADOPT, OR NOT TO ADOPT
THE CASE STUDY OF THE IMPROVED CORN SEEDS IN CHIAPAS (MÉXICO)

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THE CASE STUDY OF THE IMPROVED CORN SEEDS IN CHIAPAS (MÉXICO)

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ABSTRACT

To increase the productivity of corn in Mexico, the adoption of the improved corn seed may play an important role. Two hundred questionnaires at farm-level were collected in Chiapas, Mexico. Factors affecting the adoption rate and when to adopt were jointly analyzed using the survival analysis approach. Results showed that 60% of farmers adopted the improved seeds over a period of 10 years. The young farmers with low family members who exhibited positive attitudes towards innovation and low risk perception are likely to adopt the new varieties. Results also showed that the NAFTA Mexican reform of agricultural policy has negatively affected the adoption decision.

Keywords: Adoption, improved maize seed, survival analysis, Mexico.

1. INTRODUCTION

The globalization and liberalization of food markets as well as the agriculture sector, in particular, has created a scenario in which the predominant position is to achieve food security from comparative and competitive advantages. Mexico has resorted to importing corn with 10.7 million tons in 2015 (SIAP, 2016), thereby increasing food dependency. Notably, one consequence of this food dependency is the potential increasing of poverty (Camberos, 2000). To improve and ensure Mexican food security policy, corn production should reach higher level that meet the increasing demand for corn.

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

Although several studies have examined the adoption and diffusion of new varieties, these studies are limited to determining the rate of adoption and the factors that affect the decisions at a given time, in general, through static analysis based mainly on Probit, Logit, or Tobit models (Ghadim et al. 2005). This paper examines the adoption behaviour of improved maize seeds over time by smallholder farmers in Chiapas, Mexico. For that end, we used survival analysis, a statistical technique which provides numerical and graphical summaries of duration data that allows the researcher to investigate the effects of explanatory variables on the duration of stay of an individual in a given state. Survival analysis, therefore, allows us to determine not only why farmers adopted improved maize seeds, but also when they adopted them and what factors influenced the observed time patterns. Also, one of the advantages of survival analysis is that it allows to study the heterogeneous decision of adoption (Klein and Moeschberger, 2003). Up to date, few studies have analyzed following this approach at Mexican agriculture level. Hattam et al. (2012) analyzed organic adoption decisions using a rich set of time-to-organic durations collected from avocado small-holders in Michoacán Mexico. In this context, analysis of the adoption behavior of maize seed farmers is still scarce. Survival analysis method is a method of statistical treatment of survival times which not only makes proper allowances for those observations that are censored, but also makes use of the information from subjects up to the time when they are censored. This technique is a useful tool that may play a significant role in generating evidence-based information on survival time. The aim of this research is to analyze the adoption rate of improved maize seeds over time through a survival analysis in one of the states with the largest corn production in Mexico. We seek to assess the influence of farmer characteristics, farm structure, farm economic data, external factors, farm management, and farm results by producer. Thus, our work contributes to previous literature by extending a survival analysis to consider farmer attitudes and risk perceptions as relevant factors in explaining the decision to convert. In this regard, attitudes and preferences are important determinants of adoption decisions (De Cock, 2005). To capture and simplify this complexity, we used the Principal Components Analysis (PCA) to reduce the data obtained from different items that describe attitudes and farmers risk behavior on an 11-points scale. The resulting factors from PCA were used as explanatory variables for modeling the adoption of the improved seed. The research is expected to provide the basis for increasing productivity and efficiency of agricultural policies, as well as to help generating and transferring technologies. A better understanding of the underlying dynamics the adoption may help improve strategies to accelerate adoption.

2. METHODOLOGY

Data was collected from a face to face survey at farm level with a sample of 200 farmers carried out during January to March 2015. The sample was stratified by four main regions (Villaflores, Chiapas de Corzo, Villacorzo, and La Concordia) and seed type (creole and improved). The survival analysis was used and the semi-parametric proportional risk Cox model was estimated. The dependent variable was the time that farmers last to adopt or not the improved seed by the date of the survey. The start date was set as the year in which the farmer was responsible for managing the activities and cultivating corn. The end period was set as the year in which the farmer adopted the improved seeds. However, for those who had not yet adopted when the study was conducted, their end year was set as censored value using the year of the survey.

The variables used were: household head age, education, information, members, the year of the last agricultural policy reform the Free Trade Agreement with North America (NAFTA) in 1994, working family members, generations in agriculture, generations in planting corn, number of courses received, total farm size, yield, attitudes, opinions and perceptions. Attitudes and risk perceptions were presented in different constructs including various affirmations in a Likert scale from 0 to 10, where 0 indicated that the farmer was not at all in agreement with the affirmations and 10 was totally in agreement. The affirmations were identified and discussed in a discussion group formed by various researchers involved in the study. The information contained in the constructs were validated (alpha of Cronbach) and reduced using a Confirmatory Principal Component Analysis (CPCA). From one hand, the affirmations regarding the farmers' opinions toward the improved seeds were: a) the revenue obtained from the improved maize are able to cover the higher production costs (Valdivia *et al.* 2015), b) planting using the improved seeds can ensure the future of farms (Valdivia e*t al.* 2007), c) seeding with improved maize seeds contributes to a positive image for the exploitation (Valdivia *et al.* 2007), d) planting the improved seeds sill increase the household income (Hellin & Bellon, 2007), e) the improved seeds have better market acceptance (Hellin & Bellon, 2007) and f) the masa-tortilla relationship is greater with the improved seeds (Salazar *et al.* 2015). On the other hand, the affirmation regarding the risks may farmer perceive from using the improved seeds were: a) the risks from market is lower (Birol *et al.* 2012), b) the risks from pest proliferation (Li *et al.* 2012), c) the risk to credit access (Smale *et al.* 1994), d) the risk from yield fluctuation (Sibiya *et al.* 2013), e) the risk from drought (Veisi *et al.* 2016) and f) the risk of production loss (Asrat *et al.* 2010).

3. RESULTS AND DISCUSSION

The first confirmatory factor regarding farmers' opinions that explained the 68% of the variability of the original variables was named "positive opinion towards the improved seeds". The second confirmatory factor regarding the risk perception that capture 56% of the total variability was named "risk lover behaviour". The Kaplan-Meier method showed that 60% of farmers using improved seeds adopted within 10 years after they were responsible for planting. Approximately 80% of farmers have changed to improved seed in the first 25 years (Figure 1).

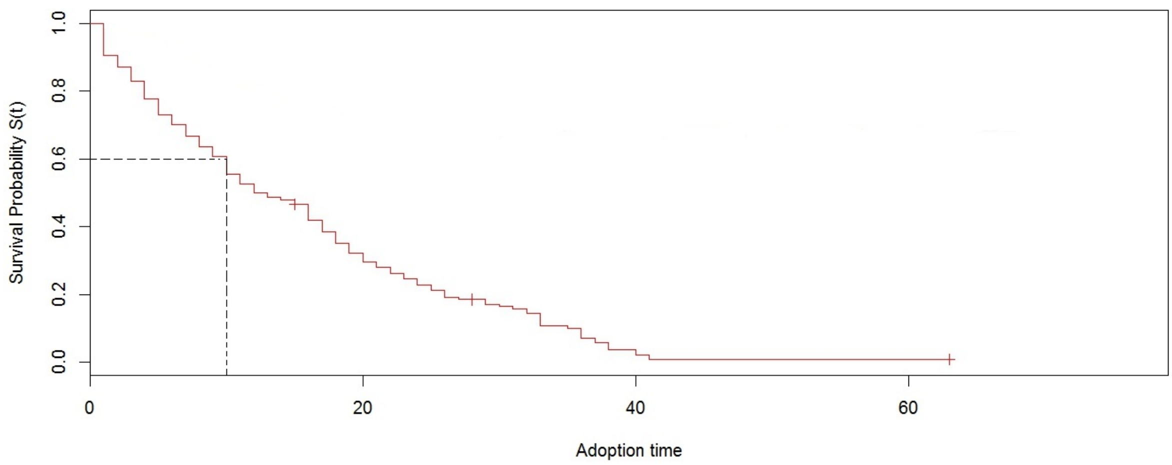

Figure 1. Kaplan-Meier survival estimate

To estimate the risk and survival functions that consider the effect of different independent variables, we used the semi-parametric proportional risk model from Cox (1972) because it does not impose any restrictions on how the baseline risk function should be and also because it performed better with our data set. The model was estimated using the different covariates available in our questionnaire. The final lists of variables included in the model are presented in Table 1. At a 95% confidence level, we rejected the null hypothesis that all coefficients are jointly equal to zero.

Table 1. Results of the Cox proportional model for the adoption of improved seeds

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

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

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

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

In the same way, our results showed that the improved seeds adoption was affected by the number of family members working in the corn production process. The higher the number of family members, the lower the adoption rate is. Farmers with the largest number of families involved in growing corn have fewer resources to invest since most of the resources are estimated to self-substance and maintenance obligations (Ouma *et al.* 2014). Due to budget constraints resulting from the high level of family expenditures (the number of the family members of creole farmers is higher), the farmers are restricted in the choices they make on which technology is employed, the degree of innovation, and their choice of crops (Feder *et al.* 1985). Our results showed that the creole household farmers have six family members, in contrast to the adopter farmers (three family members). These results help in understanding that they are forced to select and save the best seed from a previous production season for their use in the following year; contrary to what happens with improved seed, which must be purchased each year to ensure expected returns. This previous result is in agreement with what Di Falco and Bulte (2011) found regarding the negative impact of family members on adoption rate. The authors mentioned that the number of family member involved in production can negatively interact with the speed of technology adoption. Mafuru *et al.* (1999) also found that the probability of adoption of maize technology in Tazmania was reduced by 1.9% for an increase in one unit of family labor. However, the literature also reflects some contrary results as in the case of Noltze *et al.* (2012) who indicated that large families provide the labor required for corn production practices, and this may increase the adoption rate of improvements at farm. Results showed that the number of courses farmers received and the extension contact on the best farming practices has a positive impact on the adoption rate. The continuous farmer contact with extension agents makes them aware of new technologies and how to apply them. Farmer perception towards innovation largely depends on their knowledge and information level which may increase their adoption rate. Farmers' knowledge on improved agricultural technology can be accelerated with the help of extension agents and farm information sources as commented by Dibba *et al.* (2015) and Kafle (2010). Likewise, other studies deem farmer objectives as relevant factors in explaining the decision to convert (Kallas *et al.* 2009); however, in our case study, this variable was not statistically significant. When analyzing farmer perception towards the improved seeds using a confirmatory Principal Component Analysis (CPA), results showed that the probability of adoption increases when perception is positive. Those who believe in the impact of the improved seeds in increasing their household income with better market acceptance of their products and higher productivity are more likely to adopt, i.e., have a higher hazard to convert. This finding is in agreement with what Parra and Calatrava (2005) found about positive attitudes positively influencing the decision to adopt. Becerril and Abdulai (2010) mentioned that the adoption of improved maize varieties helped increase the household per capita income by 136–173 Mexican pesos, as an average; thereby reducing their probability of falling below the poverty line by roughly 19–31%.

Regarding the farmers risk behavior variable, the results of the confirmatory PCA showed that farmers that exhibit risk-loving behavior are more likely to adopt technological innovations. These results are similar to those obtained by Brick and Visser (2015) who showed that farmers who are risk averse are less likely to use modern agricultural inputs and to adopt technological innovations. This result is also in agreement with Albert and Duffy (2012) who found that risk aversion increases with age and decreases with increasing cognitive ability (Dohmen *et al.* 2010).

4. Conclusions

Our results showed that 60% of farmers adopted the improved seeds within the first 10 years after they were responsible for the farm. Likewise, our study confirmed that young farmers with low numbers of family members and high numbers of generations, who are dedicated to agriculture, has sufficient information about innovation, and are willing to take risks, are more likely to adopt improved seeds. Results also revealed the incapacity of the agricultural reform of NAFTA in 1994 to ensure sustainable economic growth. This reform decreased the rate of adoption of improved seeds, which could be because the non-adopter farmers suffered from an increase in production costs. Furthermore, small producers of corn during the transition period of NAFTA reforms were exposed to high levels of market volatility and uncertainty. Accordingly, future trade agreements should be accompanied by policies that protect the most vulnerable small farmers.

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

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