Farmers' preferences for genetically modified corn in Brazil: the contribution of latent attitudes

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Resumo
Este trabalho analisa os impactos das atitudes nas preferências dos produtores por biotecnologia, estudando o caso dos produtores de milho no Brasil. Atenção especial é dada às diferenças entre milho geneticamente modificado (GM) – Bt e RH (resistente a herbicida) – e milho não geneticamente modificado (não-GM) – híbrido e variedade. A hipótese central do trabalho é que, além de motivações econômicas, atitudes em relação ao ambiente, à pesquisa científica e às instituições também afetariam as preferências por sementes GM. As análises baseiam-se em dados primários obtidos de 300 questionários aplicados nas principais regiões produtoras do país. Primeiro, os produtores foram questionados a respeonder 17 questões em uma escala do tipo *Likert* com 5 níveis de concordância (de "concorda plenamente" até "discorda plenamente"). A análise fatorial identificou 5 atitudes latentes entre essas variáveis observáveis que discriminavam os produtores em relação ao conhecimento de sementes GM, confiança em instituições agrícolas, ceticismo em relação ao meio ambiente, percepção de risco e confiança na pesquisa científica. A confiança nas instituições agrícolas e a percepção de risco tendem a ser maiores entre os produtores GM. Ademais, os produtores de sementes Bt tendem a ser mais céticos em relação ao meio ambiente. Posteriormente, o trabalho estimou os determinantes das preferências declaradas dos produtores a partir da ordenação de suas avaliações em relação ao tipo de semente que estariam mais propensos a adotar. Os produtores tendem a ser avessos a mudanças no tipo de semente que já cultivam. Entretanto, atitudes relacionadas à confiança na pesquisa científica, o conhecimento de sementes GM e o ceticismo ambiental mostraram-se significativas em determinar a propensão a adotar sementes GM.
Palavras-chaves: milho geneticamente modificado, preferências declaradas, preferências reveladas, análise fatorial, análise conjunta

Abstract
This paper analyzes how attitudes affect farmers' preferences for biotechnology, examining the case of corn growers in Brazil. Special attention is paid to the differences between those who grow genetically modified (GM) corn - Bt and HR (herbicide resistance) – and those who grow non-genetically modified (NGM) corn – hybrid and variety. The hypothesis is that, besides economic motivations, attitudes toward the environment and scientific research also affect the preferences for GM seeds. Analyses are based on a primary database obtained from 300 corn growers in the main producing regions in Brazil. First, farmers were asked to answer 17 questions in a 5-point Likert-type scale of agreement (from "totally agree" to ''totally disagree"). Factor Analysis identified five latent attitudes among these observable variables that discriminate the farmers in

relation to the familiarity with GM seeds, trust in agricultural agencies, environmental skepticism on risk perception and trust in scientific research. The trust in agricultural agencies and the risk perception tend to be higher among GM growers. Moreover, farmers using Bt seeds tend to be more environmentally skeptic. Next, we estimated the determinants of the farmers' stated preferences based on their rank-ordered evaluations in relation to the types of corn seed they were more willing to adopt. Farmers are usually not likely to choose a different type of seed. However, trust in scientific research, familiarity with GM seeds and environmental skepticism showed significant and positive impacts on the propensity to adopt GM seeds.
Keywords: genetically modified corn, stated preferences, revealed preferences, factor analysis, conjoint analysis

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INTRODUCTION

The commercial liberalization of genetically modified (GM) corn cultivars in Brazil began in 2007, starting the diffusion process of varieties resistant to pest insects in the 2008/09 crop in regions of large production. The diffusion rate for the 2008/2009 crop was estimated at 19%, and the estimate for 2011/12 was close to 70% (Galvao, 2012). The corn production plays an important role among large and small farmers in Brazil (Miranda et al., 2012), and the GM cultivars has shown higher efficiency in comparison with conventional ones, reducing risks and increasing productivity (Pavao & Ferreira-Filho, 2011).

In spite of the significant socioeconomic impacts of the GM adoption, there are still few studies analyzing their determinants and the potential acceptance of these cultivars among farmers (Birol et al., 2008; Skevas et al., 2012). Studies usually highlight how consumers' perceptions and attitudes towards GM products affect the willingness to pay or accept GM products (a review of the main studies is presented by Smale et al. 2009). A general conclusion is that, besides socioeconomic motivations, preferences can be affected by general concerns, such as environmental attitudes, perceived risks, trust in scientific research and institutions (Chen et al., 2007).

This paper is pioneer in evaluating the determinants of stated and revealed preferences of farmers by GM seeds in Brazil. More specifically, the paper analyzes how attitudes toward the environment, trust in agriculture agencies and scientific research may affect growers' preferences for biotechnology, examining the case of corn production in Brazil. Special attention is paid to the characteristics that differentiate the small growers of genetically modified (GM) corn - Bt (*bacillus thuringiensis*) and HR (*herbicide resistant*) - and non-genetically modified corn (non-GM) – hybrid and variety.

The hypothesis under analysis is that, besides economic motivations, such as capital (land size) and costs (seed prices and royalties), those farmers who derive the lowest values from environmental diversity, as well as the highest values from trust in scientific research and agricultural institution are more likely to accept GM seeds. Making this analysis, the paper contributes to the literature in three ways. First, it is the first applied economics study to investigate the determinants of GM seeds among farmers in Brazil. Second, this study adds to the growing literature that employs the choice experiment method to estimate stated preferences for biotechnology (Louviere et al., 2000). Third, it provides important elements to orientate decision making in biotechnology policies for the agricultural sector in Brazil.

Analyses are based on a primary database obtained from 300 small and medium farmers in the main producing regions in Brazil. Since production is highly concentrated in this sector, this sample can be considered fairly representative of the universe of these corn producers in Brazil. We used Factor Analysis to identify latent attitudes and Conjoint Analysis to estimate the determinants of the stated preferences for GM seeds.

1. ATTITUDES TOWARD GM PRODUCTS

Attitudes are recognized as one of the main factors guiding human behavior (Bredahls, 2001). Since behavioral intentions reflect individuals' preferences and choices in the market, it is reasonable to expect that the use and consumption of GM products will be influenced by general and specific attitudes towards GM products. While there are many studies addressing the impacts of attitudes on GM acceptance among consumers in developed and developing countries (for instance, Kikulwe et al., 2011; Krishna and Qaim, 2008; Angulo and Gil, 2007; Chen and Li, 2007; Cook et al., 2002; Quan, 2002), there are still few researches on the producer side (for instance, Birol et al., 2008; Skevas et al., 2012).

GM cultivars are a relatively new phenomenon in Brazil and many farmers, especially in the less developed regions, had not yet the opportunity to actually analyze the costs and benefits of GM seeds. Indeed, individuals with very limited experience about technology are more likely to be influenced by their general attitudes before accepting their products (Bredahls, 2001; Gaskell, 1999). Moreover, limited knowledge about GM technology may heighten risk perception and reduces acceptance of GM products (Gaskell et al., 1999).

Attitudes towards the use GM products may also express more fundamental beliefs, directly related to more general attitudes, such as attitudes towards environment, technology and institutions (Frewer et al., 1997; Chen and Li, 2007).For instance, Siegrist (2000) suggests that public attitudes toward emerging technologies, such as GM products, are mainly driven by people's trust in the institutions promoting these innovations and regulating its risks. Gaskell et al. (1999) have also found evidences that trust in regulatory authorities may help explain the public concern about GM products.

According to Frewer et al. (1997), the increased environmental concern is a phenomenon that is likely to increase public resistance to emerging technologies, and thus, affect preferences for GM products. Opposition to the use of GM technology, especially for food production, has centered on the not yet proven belief that this technology poses unacceptable risks to the environment (Cook et al., 2002). In Brazil, there are rural organized movements, such as the MST (*Movimento dos Trabalhadores Rurais sem Terra*), that vehemently opposes the use of GM crops and their though may affect small farmers preferences.

Finally, it is also worth considering the effects of perceived benefits and perceived risks on GM acceptance. Perceived benefits are believed to be crucial for the acceptance of new technologies (Chen and Li, 2007). Since GM seeds may reduce risks concerning the rise of pest or the use of herbicides, they would be more likely to be accepted among farmers with higher risk perception.

2. MATERIAL AND METHODS

Our analyses were based on 300 questionnaires applied to corn producers in the main Brazilian producing regions (50 questionnaires in the state of Bahia, 45 in the state of Goiás, 42 in Maranhão, 96 in Minas Gerais and 67 in Santa Catarina). The sample was based on producers with no more than 5 hectares (57% of the sample). Large producers were, however, also represented in the sample with those with more than 50 hectares of corn planted representing 11%.

Since there was no accurate information about farmers' characteristics for each type of cotton production in Brazil, we designed a non-probabilistic sample. Sample units were selected according to information provided by experts from the EMBRAPA (Brazilian Agricultural Research Corporation), technicians and representatives of regional cooperatives of cotton producers. The types of corn most frequently cultivated in the sample of producers were hybrid (115 producers, or 38%) and variety (105, or 35%). Producers cultivating GM corn seeds represented 26% of the sample (79 producers) and they were predominantly Bt growers (71 producers), since the use of the HR technology was still very rare in Brazil (11 producers in the sample).

1.1.FACTOR ANALYSIS

Factor Analysis (FA) allowed us to identify latent attitudes of farmers in relation to the environment, biotechnology, institutions and perceived risks. Seventeen questions were presented to the farmers, who evaluated their level of agreement in relation to each of them in a likert-scale (see Table 2). The FA was then applied in order to obtain *m* common factors F that could reasonably explain the total variability of the n (n=17) observable variables X.

The FA assumes that the observable variables X can be expressed by linear combinations of unobservable and uncorrelated factors F (Kim & Mueller, 1978). In other words:

$$X_i = a_{i1}F_1 + ... + a_{im}F_m + d_iU_i \qquad (1)$$

Where a is the factor loading and expresses the relationship between the observable variables and the unobservable factors F. Factors F are also called common factors, since they contribute to explain the variability of the n observable variables. Variables U are called unique factors, because each unique factor U_i affects only the variability of a single observable variable X_i and expresses the behavior not explained by the common factors.

Other useful variables to understand the results of the FA are the final commonality (h^2) and the total variability explained by each factor (λ) (Cuadras, 1981). Commonality represents the share of the total variability of the i-th observable variable X_i explained by the m common factors F. Total variability explained by each factor represents the discriminatory power of the j-th factor over all observable variables. It is also usually expressed in relative terms, i.e., as a percentage of the total variability of observed variables.

We used the principal component factor analysis (PCF) to obtain the common factors F, due to its operational simplicity and the analytical consistency of its results in our case. First, this technique gives the factor F_1 that contributes the most to explain the variability of the n observable variables X. Second, considering just the variability not explained by F_1, PCF finds the factor F_2 using the same criteria, and so on, until obtaining the m factors that explain 100% of the total variability of the n observable variables.

The factor loadings a are used to interpret the meaning of the factors, considering their linear relation and their relevance in predicting each observable variable X. The process of rotation is usually used to facilitate the interpretation of the factors. Rotation is a linear transformation that sometimes provides new factors that are able to make the relationship between the factors and the observed variables more clear and objective, with no impact on the explanatory power of these factors. We used the varimax technique to rotate the factors, which maximizes the sum of the variance of the square coefficients.

1.2.CONJOINT ANALYSIS

We applied CA to evaluate how farmers estimate their preferences in terms of the corn production system. Data were collected by asking farmers about their preferences for different characteristics of cotton systems. The CA decomposes the rank-ordered evaluation judgments of corn systems into components based on their qualitative characteristics. For each characteristic of interest, a numerical "part-worth utility" value is computed. The sum of the part-worth utilities for each product is an estimate of its utility. The aim is to compute part-worth utilities in such a way that the product utilities are as similar as possible to the original rank ordering.

Different formats of choice studies can be applied, for instance: contingent choice, contingent rating and contingent ranking (Gonzales et al., 2004). Contingent choice asks the interviewee to report a choice from a set of alternatives. This format provides weakly ordered data, since only one response does not allow a complete preference ordering (Louviere et al., 2000). In the rating format, the interviewee rates each set of alternatives on a category of the ?? rating scale. Although data in this format are less weakly ordered than in the contingent choice, it makes very strong assumptions about human cognitive abilities (Louviere et al., 2000). We preferred contingent ranking, which asks consumers to rank a set of alternatives. This format provides a complete preference order, albeit with no information about differences in the degree of preferences.

In our contingent survey, respondents were asked to rank a set of alternatives, describing different characteristics of the corn production. Two attributes of interest were considered: *type* of cotton and *price* (Table 1). The attribute *type* represents the four most commonly produced corns in Brazil: GM Bt, GM HR, hybrid and variety. The attribute *price* expresses variations in the average price of the seeds in Brazil: lower than average (between 15 and 20% lower), average value and higher than average (between 15 and 20% higher). For GM seeds, we also considered the payment of royalties (R$ 80/hectare). Such a design would imply a total of 81 possible alternatives (3 prices for each type = 3^4), which were randomly distributed in sets of four alternatives for each interviewee.

Table 1 – Corn attributes in the contingent ranking

Type	Price
Bt	Lower (R$ 180 / bag + R$ 80 royalty)
	Average (R$ 230 / bag + R$ 80 royalty)
	Higher (R$ 280 / bag + R$ 80 royalty)
HR	Lower (R$ 180 / bag + R$ 80 royalty)
	Average (R$ 230 / bag + R$ 80 royalty)
	Higher (R$ 280 / bag + R$ 80 royalty)
Hybrid	Lower (R$ 110 / bag)
	Average (R$ 130 / bag)
	Higher (R$ 150 / bag)
Variety	Lower (R$ 50 / bag)
	Average (R$ 60 / bag)
	Higher (R$ 70 / bag)

We modeled farmers' preferences for each type of seed using the rank ordered probit model (ROP). First, suppose U_{ij} representing the utility of the *j*-th choice to the *i*-th individual. We can assume that U_{ij} is a random variable with a systematic component η_{ij} and an unpredictable random component ε_{ij}, such that (RODRIGUEZ, 2012):

$$U_{ij} = \eta_{ij} + \varepsilon_{ij} \qquad (2)$$

Although utility *U* is not measurable in the contingent ranking experiment, we can predict the probability of choosing an alternative *j* in comparison with an alternative *k*. Farmer *i* will choose alternative *j* in comparison with alternative *k* if U_{ij} is higher than U_{ik}. Thus, if Y_i represents the choice of the farmer *i*, the probability of choosing alternative *j* can be expressed by:

$$\Pr(Y_i = j) = \Pr(U_{ij} > U_{ik}) \qquad (3)$$

Making some assumptions about the distribution of the error term ε_{ij}, we can model this probability by (Maddala, 1983):

$$\Pr(Y_i = j) = \frac{e^{\eta_{ij}}}{e^{\eta_{ik}}} \tag{4}$$

In turn, the systematic utility η_{ij} can be modeled as a function of the characteristics of the individuals ($\mathbf{x}_i$) and characteristics of the alternatives ($\mathbf{z}_j$):

$$\eta_{ij} = \mathbf{x}_i \beta_j + \mathbf{z}_j \delta \tag{5}$$

Thus, the coefficients β_j express how the acceptance of the alternative j is affected by individuals' characteristics $\mathbf{x}$ and δ express how the acceptance is influenced by the alternatives' characteristics $\mathbf{z}$.

3. RESULTS

The level of agreement of the farmers in relation to several questions is presented in Table 2. Results highlight, for instance, that the great majority of the farmers (85% or higher) see positively the role of scientific research on human life and agricultural production, as well as they tend to agree that pesticides cause negative impacts on human health. On the other hand, an expressive share of farmers (32%) does not believe that agriculture causes serious damages in the environment.

Table 2 – Questions about the environment, agriculture and technology - distribution of farmers (row %)

Question	Totally Agree	Parcially Agree	Neutral	Parcially Disagree	Totally Disagree
1. The scientific research has improved agricultural production	70.5	19.0	5.8	2.4	2.4
2. The scientific research has improved human life.	63.4	22.0	7.8	4.1	2.7
3. The humans have caused serious damage to the environment.	68.0	18.4	6.1	3.1	4.4
4. Agricultural production has caused serious damage to the environment.	32.9	27.7	7.5	9.6	22.3
5. The use of pesticides in agriculture has caused serious health problems.	73.2	11.3	6.5	2.4	6.5
6. Government policies on agriculture are reliable.	21.6	21.9	17.5	13.0	26.0
7. The public agencies that develop agricultural research are reliable.	53.1	19.0	15.3	6.5	6.1
8. Private companies that produce seeds for agriculture are reliable.	39.0	19.9	16.1	11.6	13.4
9. There are corn seeds that are resistant to agricultural pests.	71.4	5.8	11.2	6.1	5.4
10. There are corn seeds that are resistant to herbicides.	66.9	8.5	14.7	3.8	6.1
11. There are corn seeds that are more productive than conventional ones.	79.3	8.8	6.3	1.7	3.9
12. There are types of corn cultivation that cause less impact on the environment.	55.8	10.5	18.0	3.8	11.9
13. The fluctuation of the price paid to the producer is always a factor of high risk in corn production.	61.6	10.9	7.5	3.7	16.3
14. The climate fluctuation is always a factor of high risk in corn production.	85.4	9.5	1.0	1.4	2.7
15. The fluctuation of the price of inputs is always a factor of high risk in corn production.	72.5	8.8	6.4	4.4	7.8
16. The rise in pests is always a factor of high risk in corn production.	69.8	17.0	3.1	5.4	4.8
17. The rise in weeds is always a factor of high risk factor in corn production	58.3	18.8	3.8	9.7	9.4

Source: Research data

Moreover, a large share of farmers does not trust in public policies on agriculture in Brazil (39%) as well as they do not trust in private companies that produces seeds (25%). The trust in public agencies, such as EMBRAPA and State agricultural agencies is high (72%).

There is a high rate of knowledge about the types of corn seeds that are resistant to pests (77%), herbicides (75%) and, in particular, about those that are more productive than conventional seeds (88%). The climate instability is seen as the main factor of risk in corn production (95%), followed by the rise of pests (87%).

Next, answers were scored from 1 (Totally Agree) to 5 (Totally Disagree) and used as observed variables in the FA. We selected 5 common factors based on the discriminatory power of each factor and on the consistence of the latent attitude represented by each one. Each factor had a marginal contribution higher than 7% and together they explained 53% of the total variability of the original variables. Based on the rotated factor loadings (Table 3), we interpreted each factor as the following latent attitudes:

Factor 1 – Unfamiliarity with GM seeds and mistrust in agricultural agencies

This is the factor that most discriminates the variability of the 17 observed variables (17%). It has a strong and positive relation with the degree of disagreement that the existence of herbicides-resistant corn seeds (Variable 10), agricultural pests (Variable 9) and the trust in public and private agencies that carry out agricultural research and produce seeds (Variables 7 and 8). Thus, the higher the value of this factor, the lower the knowledge about the existence of GM seeds and the trust placed in agricultural agencies.

Factor 2 – Environmental skepticism

This factor discriminates 12% of the total variability of the 17 observed variables. It has a strong and positive relation with the degree of disagreement that the use of pesticides has caused serious health problems (Variable 5) as well as the agriculture and the humans have caused serious environmental damages (Variables 5 and 4). Thus, the higher the value of this factor, the higher the skepticism about the impacts of human life and agricultural production on the environment.

Factor 3 – Lack of risk perception

This factor discriminates 9% of the total variability of the observed variables. It has a strong and positive relation with the degree of disagreement with the statement that the instability of the price of inputs, climate and price paid to producers represent high risks to corn production (Variables 15, 14 and 13). It also has a positive relation, to a lesser extent, with the unfamiliarity with seeds that are more environmentally friendly (Variable 12). We can assume that the higher the value of this factor, the higher the lack of risk perception.

Factor 4 – Mistrust in scientific research

This factor discriminates 8% of the total variability. It has a strong and positive relation with the degree of disagreement that scientific research has improved agricultural production (Variable 1) and human life (Variable 2). Thus, the higher the value of this factor, the higher the level of mistrust in scientific research.

Factor 5 – Lack of risk of pests and weeds

This factor discriminates 7% of the total variability and has a strong and positive relation with the disagreement that pest and weeds represent a high risk in corn production (Variables 16 and 17). Thus, the higher the value of this factor, the lower the perceived risk of pests and weeds in corn production.

Table 3 – Rotated factor loadings and unique variances

Question	Factor1	Factor2	Factor3	Factor4	Factor5	Uniqueness
1	0.134	-0.028	0.088	0.829	0.067	0.282
2	0.044	-0.035	0.017	0.830	0.046	0.306
3	-0.021	0.679	0.087	0.258	-0.138	0.445
4	0.020	0.739	-0.046	-0.120	0.194	0.400
5	0.000	0.753	-0.078	-0.113	0.136	0.396
6	0.350	0.016	-0.167	-0.098	0.383	0.693
7	0.598	-0.204	-0.070	0.170	0.161	0.542
8	0.496	-0.423	-0.136	0.164	0.227	0.478
9	0.663	0.022	0.248	0.240	-0.073	0.435
10	0.712	0.129	0.155	-0.063	-0.161	0.423
11	0.494	-0.011	0.124	0.254	0.160	0.651
12	0.254	0.074	0.511	0.092	-0.089	0.653
13	-0.023	-0.088	0.568	0.108	0.247	0.597
14	-0.012	0.064	0.639	0.014	0.188	0.552
15	0.140	-0.050	0.802	0.057	-0.036	0.330
16	0.097	0.059	0.073	0.004	0.772	0.387
17	-0.189	0.142	0.072	0.200	0.695	0.416

Source: Research data

The factor scores vary substantially according to the type of corn cultivated by the farmer (Table 4). For instance, as would be expected, the degree of unfamiliarity with GM seeds and mistrust in agricultural agencies (Factor 1) is higher among those farmers that do not cultivate GM seeds. Moreover, Bt farmers tend to show a higher degree of environmental skepticism (Factor 2) and have greater trust in scientific research (Factor 4).

The risk perception with climate and prices (Factor 3) is higher among GM farmers, which could justify their choice for seeds that are resistant to weeds and herbicides. In turn, there is no relevant pattern of relationship between the type of production and the risk perception for pests and weeds (Factor 5).

Table 4 – Average factor scores for types of corn producers

Producer	*Factor1*	*Factor2*	*Factor3*	*Factor4*	*Factor5*	n^*
Bt	-0.323	0.575	-0.391	-0.162	0.047	64
HR	-0.220	-0.137	-0.272	0.252	0.310	10
Hybrid	0.017	-0.005	0.033	-0.097	0.171	105
Variety	0.468	-0.160	0.355	0.190	0.013	86

Source: Research data

* One farmer can cultivate more than one type of corn seed

Next, we estimated the determinants of the farmers' stated preferences based on their rank-ordered evaluations for the type of corn seed they were more willing to adopt. The interest variable in our ordered probit model is the probability of choosing a specific alternative in comparison with other alternatives. For each farmer, we had four ranked choices of corn seeds (Bt; HR; Hybrid and Variety), providing us multiple pairs of comparison.

Two dummy variables were used to discriminate the characteristics of the alternative types of seeds:

i) *Lower*: 1 for price lower than the average value usually charged and 0 otherwise;
ii) *Higher*: 1 for price higher than the average value usually charged and 0 otherwise;

And ten variables were initially considered to discriminate the farmers' characteristics:

i) *Area*: total area of cultivated corn in hectares;
ii) *D_Bt*: dummy variable that values 1 if farmer cultivates Bt corn and 0 otherwise;
iii) *D_TH*: dummy variable that values 1 if farmer cultivates HR corn and 0 otherwise;
iv) *D_Hybrid*: dummy variable that values 1 if farmer cultivates Hybrid corn and 0 otherwise;
v) *D_Variety*: dummy variable that values 1 if farmer cultivates Variety corn and 0 otherwise;
vi) *Factor1-Factor5*: scores for the five common factors identified in the FA;

Since there would be high colinearity among these variables, especially between the type of production and the latent factors, we fitted two rank-ordered probit regression models: a restricted and an unrestricted model. The unrestricted model (Model 1) used all controlled variables and the restricted model (Model 2) do not consider the dummies *D_Bt*, *D_HR*, *D_Hybrid* and *D_Variety*. Bt corn was chosen to be used as a reference in our analysis. Thus, positive coefficients mean higher preferences for alternative *j* in comparison with Bt.

Maximum likelihood estimates are presented in Table 5. The insignificant estimates for the coefficients related to variables *Lower* and *Higher* suggest that small changes in the price of the seeds have no significant effect on the stated preferences of the farmers for different types of seeds. Three factors must be considered to help explaining these results: i) the low variability in relation to average prices; ii) the high variability of prices charged among Brazilian regions; iii) the institutional arrangement of the production. This means that all alternative prices presented to the farmers in a specific region would be lower or higher than the national average price used as reference.

Producers with larger cultivated areas are more likely to adopt Bt corn. Moreover, dummy variables for the type of corn cultivated in the farm (*D_Bt*, *D_HR*, *D_Hybrid* and *D_Variety*) suggest that the revealed choice for GM corn has a positive impact on the stated preferences for this kind of seed. In other words, those farmers cultivating GM seed are less likely to choose a non GM seed.

Some attitudes show significant impacts on the choice for GM seeds. For instance, with other factors remaining constant, farmers with a lower risk perception of price and climate (Factor 3) are less likely to adopt non-GM seeds (Hybrid and Variety). However, this effect disappears when we do not control the type of seed cultivated in the farm.

The mistrust in scientific research (Factor 4) is positively related to the choice of non-GM seeds. In other words, farmers who trust in scientific research are more likely to adopt GM seeds. Moreover, the lack of risk of pests and weeds (Factor 5) in the farm seems to affect positively the choice of Variety corn in comparison to Bt corn.

Finally, the familiarity with GM seeds and environmental skepticism are significant in the restricted model (Model 2). In this model, the lower the familiarity with GM seeds (Factor

1), the higher the propensity to adopt Variety corn in comparison with Bt corn. Moreover, the higher the environmental skepticism, the higher the propensity to adopt Bt corn in comparison with Variety corn.

Table 5 – Maximum likelihood estimates for rank ordered probit model

	Variable	Model 1					Model 2				
		Coef.	SE	Z	P>|z|		Coef.	SE	z	P>|z|	
Alternatives											
	Lower	-0.095	0.145	-0.65	0.514		-0.085	0.145	-0.58	0.560	
	Higher	-0.131	0.132	-0.99	0.322		-0.098	0.131	-0.75	0.454	
Farmers											
HR	Constant	0.081	0.242	0.33	0.738		-0.093	0.152	-0.61	0.540	
HR	Area	-0.009	0.004	-2.18	0.029	**	-0.010	0.004	-2.63	0.009	***
HR	D_Bt	-0.651	0.333	-1.95	0.051	*					
HR	D_HR	0.013	0.580	0.02	0.983						
HR	D_Hybrid	-0.036	0.257	-0.14	0.888						
HR	D_Variety	-0.139	0.282	-0.49	0.622						
HR	Factor1	0.035	0.116	0.3	0.765		0.046	0.111	0.41	0.680	
HR	Factor2	0.108	0.122	0.88	0.377		0.057	0.118	0.49	0.628	
HR	Factor3	-0.140	0.117	-1.19	0.233		-0.111	0.147	-0.75	0.453	
HR	Factor4	-0.008	0.110	-0.07	0.945		-0.003	0.114	-0.02	0.982	
HR	Factor5	0.090	0.109	0.82	0.413		0.073	0.111	0.66	0.511	
Hybrid	Constant	1.158	0.375	3.09	0.002	***	0.866	0.215	4.03	0.000	***
Hybrid	Area	-0.018	0.006	-3.16	0.002	***	-0.026	0.006	-4.16	0.000	***
Hybrid	D_Bt	-2.236	0.518	-4.32	0.000	***					
Hybrid	D_HR	-2.927	0.966	-3.03	0.002	***					
Hybrid	D_Hybrid	-0.046	0.381	-0.12	0.904						
Hybrid	D_Variety	0.579	0.424	1.37	0.172						
Hybrid	Factor1	-0.236	0.170	-1.39	0.165		0.018	0.177	0.1	0.918	
Hybrid	Factor2	0.002	0.177	0.01	0.991		-0.185	0.186	-0.99	0.320	
Hybrid	Factor3	-0.560	0.177	-3.17	0.002	***	-0.290	0.217	-1.34	0.181	
Hybrid	Factor4	0.305	0.169	1.81	0.071	*	0.335	0.189	1.78	0.075	*
Hybrid	Factor5	0.212	0.166	1.27	0.203		0.134	0.183	0.73	0.465	
Variety	Constant	0.802	0.475	1.69	0.091	*	0.065	0.265	0.25	0.806	
Variety	Area	-0.023	0.008	-2.94	0.003	***	-0.038	0.009	-4.13	0.000	***
Variety	D_Bt	-4.070	0.794	-5.13	0.000	***					
Variety	D_HR	-3.509	1.246	-2.82	0.005	***					
Variety	D_Hybrid	-0.638	0.505	-1.26	0.206						
Variety	D_Variety	0.913	0.555	1.64	0.100						
Variety	Factor1	0.008	0.224	0.04	0.971		0.400	0.239	1.67	0.095	*
Variety	Factor2	-0.110	0.243	-0.45	0.652		-0.446	0.262	-1.7	0.089	*
Variety	Factor3	-0.724	0.237	-3.06	0.002	***	-0.281	0.269	-1.05	0.295	
Variety	Factor4	0.382	0.221	1.73	0.084	*	0.486	0.239	2.03	0.042	**
Variety	Factor5	0.666	0.233	2.86	0.004	***	0.498	0.242	2.06	0.040	**

Source: Research data

*** Significance at 1%; ** Significance at 5%; * Significance at 10%

CONCLUSIONS

This study provided important elements to understand how the revealed and stated preferences of corn farmers in Brazil are affected by general and specific attitudes toward GM technology. First, results highlighted that these farmers tend to optimistically see the role of scientific research on human life and agriculture in Brazil. Although they are skeptical in relation to the impacts of agriculture on the environment, they are more pessimistic about the impacts of pesticides on the human health. Moreover, the climate and the rise of pests are seen as the main factors of risk in the corn production.

As would be expected, there is a positive relation between the knowledge of GM technology and the use of GM seeds. As suggested by Gaskell et al. (1999), limited knowledge about GM technology tends to increases risk perception and reduces acceptance of GM seeds. On the other hand, the knowledge of GM technology cannot be pointed as the main responsible for low adoption of GM seeds in Brazil, since most of the farmers, GM and non-GM, are aware of the existence of resistant corn seeds (between 80% and 90%).

Latent attitudes identified by the FA discriminated the farmers in relation to their familiarity with GM seed, trust in agricultural institutions, environmental skepticism, trust in scientific research and risk perception of pests and weeds. The trust in agricultural institutions is higher among those farmers who cultivate GM seeds, as well as the trust in scientific research tends to increase the acceptance for GM seeds. As suggested by Frewer et al. (1997), public recognition of the tangible benefits of new technologies is likely to mediate perceptions of associated risk and, thus, also affect the acceptance of GM products.

Bt farmers tend to be more environmentally skeptic and have a greater trust in scientific research. Moreover, the higher the environmental skepticism, the higher the propensity to adopt Bt corn in comparison with Variety corn. These results deserve two main considerations. First, it suggests that, besides economic factors, farmers also consider the impacts of their choices on the environment and the consequences for future generations. Second and the most important, it highlights the need to stimulate researches on biotechnological safety to oppose the common sense that GM practices may impose risks to environment and human health.

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