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Do European Union Farmers Reject Genetically Modified Maize? Farmer Preferences for Genetically Modified Maize in Greece

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The new EU proposal (IP/10/921) states that bans on genetically modified (GM) crops should not be based on environmental and health grounds, and it proposes a set of alternative reasons—including public order and morals—that can be cited by member states. This reveals the increasing importance of stakeholders' attitudes in GM crops' release decisions. This article analyzes farmers' attitudes and perceptions toward GM maize based on a survey of large-area Greek farmers in Northeastern Greece. A considerable number of respondents (61%) would adopt GM maize if Greece lifts the ban on GM maize cultivation. This result opposes recent findings from countries strongly opposing GM crops (such as France and Hungary), where bans are in line with the majority view of farmers. The ban is against what the majority of large-area farmers in Greece would choose if allowed.

Key words: cluster analysis, factor analysis, GM maize, GM cultivation ban, Greece, perceptions.

Introduction

Genetically modified organisms (GMOs) can be defined as organisms that have (typically) been genetically modified in order to provide resistance to certain insect pests and provide tolerance to total herbicides (EUROPA, 2007). To date, the only GM crops growing in the European Union (EU) are MON810 maize and Amflora, a GM potato. The MON810—or so-called "Bt maize"—is a genetically modified maize variety that contains an insecticidal protein that occurs naturally in *Bacillus thuringiensis*. This protein, known as Bt delta endotoxin, is fatal for Lepidoptera larvae—in particular, European (ECB) and Mediterranean corn borer (MCB). Corn borers cause severe plant damage by penetrating the stalk and complicating the circulation of nutrients and water. Stalk or cob penetration renders their chemical control difficult, as it shortens the time that they are vulnerable to sprays or residues (Jansens et al., 1997).

The issue of farmers' and consumers' attitudes towards GM food is not new, with a considerable number of studies analyzing it in both developed (Areal, Riesgo, & Rodriguez-Cerezo, 2011; Breustedt, Müller-Scheeßel, & Latacz-Lohmann, 2008; Marra, Hubbel, & Carlson, 2001; Weaver, 2005, among others) and developing countries (Curtis, McCluskey, & Wahl, 2004; Ho & Vermeer, 2004; Kikulwe, Wesseler, & Falck-Zepeda, 2011; Kolady & Lesser, 2006; Qaim & de Janvry, 2003, among others). Europeans are divided over GM food and crops (Eurobarometer, 2010). Costa-Font, Gil, and Traill (2008)—in a review of GM food's and GMOs' public acceptability—showed that among EU countries, Spain and Portugal are more tolerant to GM food compared to France and the Nordic countries. A recent Eurobarometer survey on biotechnology showed that although Greek consumers believe that biotechnology and genetic engineering will have a positive effect on their way of life in the next 20 years (51%), they are not in favor of developing GM food (72%) and characterize it as "not good" (78%; Eurobarometer, 2010).

In 2009, Bt maize was grown on nearly 94,750 hectares (ha) in Spain, Portugal, the Czech Republic, Slovakia, Romania, and Poland (GMO Compass, 2010b). Bt maize was cultivated in France and Germany until 2007 and 2008, respectively, when national cultivation bans were enacted (GMO Compass, 2010b). France, Germany, Austria, Greece, Hungary, and Luxembourg have banned Bt maize.

Greece banned Bt maize by making use of the safeguard clause[1] according to the EU directive on the release of GMOs (2001/18/EC, Article 23). In support of this ban, Greek authorities provided information raising the potential impacts of Bt maize on bee colonies and on animals fed with Bt maize (GMO Compass, 2010a). The European food safety authority (EFSA) reviewed this information and decided that their claims

1. *"This safeguard clause provides that where a Member State has justifiable reasons to consider that a GMO, which has received written consent for placing on the market, constitutes a risk to human health or the environment, it may provisionally restrict or prohibit the use and/or sale of that product on its territory" (EUROPA, 2007, p. 6).*

were not scientifically substantiated (EFSA, 2008). In 2009, the European Commission (EC) tried to force France, Greece, Austria, and Hungary to lift bans on growing Bt maize but could not muster the majority votes of member states needed.[2] Thereafter, a package of proposals was put forward, where the EC will keep approving GM crops (based on scientific advice from EFSA) but will enable EU member states to choose whether they will approve them for cultivation (Proposal IP/10/921). According to the new proposal, if member states decide to ban GM crops, they should not base their decision on health or environmental grounds. A draft list for acceptable reasons for a ban prepared by the EU Commission includes seven reasons: public order, public morals, ensuring consumers can buy GM-free products, town and country planning, preservation of farming diversity, cultural and historical heritage, and vaguely-defined "social policy objectives" (Rankin, 2011). Public order and morals constitute the only reasons from the proposed list that are part of the general exceptions[3] to the World Trade Organization (WTO) norm of trade liberalization (Marwell, 2006). As a result, these might be the only reasons from the list that could possibly withstand a legal challenge in the WTO. Greek authorities could ban the cultivation of GM crops to maintain public order in the face of popular opposition to the technology. An important question is whether public opinion in Greece is against the release of GM crops and food. In an effort to reveal public opinion on GM technology, both consumers' and producers' attitudes should be considered.

While there are studies that address the issue of acceptability of GM products from Greek consumers (Antonopoulou, Papadas, & Targoutzidis, 2009; Arvanitoyannis & Krystallis, 2005; Batrinou, Spiliotis, & Sakellaris, 2008), there is a lack of research on the food-producer side. This study tries to fill this gap by exploring farmers' willingness to adopt Bt maize in Greece. This will enable a comparison of producers' and consumers' attitudes toward GM maize and reveal if there is a consensus regarding the rejection of GM crops in Greece that can justify the use of the "public order or morals" claim to ban GM maize and supports the argument "farmers do not want" the technology. Additionally, the study tries to ascertain the perceptions and characteristics of farmers who are likely to grow Bt maize; doing so contributes to the debate of GM crops' approval in the EU. This article discusses the benefits, costs, and externalities of GM maize adoption. Then, the methodology followed in this study is presented and information on the study area and the collected data is provided. Results are analyzed, followed by discussions and conclusions.

Benefits, Costs, and Externalities of GM Maize Cultivation

The reduced application of insecticide is a major direct benefit of GM crops that are insect resistant. Less insecticide use reduces farmers' exposure to chemicals (Hossain et al., 2004; Huang, Hu, Rozelle, & Pray, 2005) and lowers pesticide residues in food and feed crops, while it also releases fewer chemicals into the environment and potentially increases on-farm biodiversity (insects and pollinators; Nickson, 2005). Additionally, a health benefit of Bt corn is the reduction of mycotoxins[4] in food and feed products (Wu, 2006). Benefits for farmers due to Bt maize adoption may also arise from off-farm income. Bt maize adoption results in crop-management simplification that frees labor, which may be directed to off-farm activities. Considering that agricultural production takes place under a stochastic environment where periods with high pest infestations are not unusual, Bt maize offers insurance against devastating crop losses. As most Bt maize in Europe is used as feed for animal production, productivity gains[5] of Bt maize cultivation can lead to increased efficiency in feed production. This may help increase animal production without increasing pressure on natural habitats.

A meta-analysis of the ex-post impact assessments of GM crops reviewed by Demont, Dillen, Mathijs, and Tollens (2007) shows that, on average, farmers and consumers capture two-thirds of the benefits of first-generation GM crops, whereas only one-third accrues to gene developers and seed suppliers. Wesseler, Scatasta, and Nillesen (2007)—in a study that assesses the ex-ante incremental benefits and costs of introducing transgenic maize in the EU-15—reported the social

2. *Getting crops approved requires a 'qualified majority' of the 27 member states that make up the European Council in favor (at least 255 from a total of 345 votes).*
3. *Other exceptions include measures that protect exhaustible natural resources; human, animal, and plant life; and health.*
4. *Mycotoxins are natural secondary metabolism products of fungi with toxic properties of carcinogenicity (Wu, 2006).*
5. *Demont and Tollens (2004) report that in the temperate growing areas, yield gains due to Bt maize are estimated at 5%. Skevas et al. (2010), in a case study of GM farmers in Portugal, report mean yield increases of 15.5%.*

incremental reversible benefits from introducing Bt and HT maize in Greece to be €11.76 and €5.44 million, respectively.

One of the costs of Bt maize cultivation is the technology fee, which represents the difference between the seed costs of Bt maize and equivalent conventional varieties. The increase in production costs due to the technology fee can be offset from yield increases (because of lower crop damage) and decreased pesticide costs. This is depicted in the case study of Skevas, Fevereiro, and Wesseler (2010) from Portugal where farmers' incremental benefits of Bt maize cultivation were on average €254/ha. The authors reported that for some of the farmers in the case study, the savings on insecticide spending alone could compensate for the technology fee impelled in the Bt seed price.

As in the EU, the property rights of planting GM crops are with the non-GM farmer, while GM farmers are faced with ex-ante and ex-post liability costs. Investing in strategies to avoid cross pollination and informing or reaching an agreement with non-GM neighbors for planting GM crops (transaction costs) are examples of ex-ante costs; ex-post liability costs involve compensation for damages caused to a neighboring field. Rigid coexistence regulations can increase ex-ante costs and decrease GM crop adoption (Demont et al., 2008; Skevas, Wesseler, & Fevereiro, 2009). In general, the existence of high or low ex-ante costs depends on the specific case under investigation. For instance, high transaction costs may arise if several non-GM neighbors are involved or they are not willing to negotiate. On the other hand, case study results from Portugal show that farmers could reduce transaction costs to zero by cultivating GM maize in bordering fields (Skevas et al., 2010). Agglomeration of GM and non-GM crops due to incentives that lower transaction costs is also referred to in the study by Beckmann and Wesseler (2007).

The environmental concerns over GM maize cultivation focus mainly on the transfer of GM traits to populations of wild plants, as well as direct or indirect effects on non-target organisms (Food and Agriculture Organization [FAO], 2003). Different GM traits cause different environmental impacts dependent on whether they confer a selective advantage or disadvantage over wild plants (Dunwell & Ford, 2005). The transfer of Bt maize's insect resistance to weedy species will undoubtedly confer an advantage over plants lacking this trait. On the other hand, the increase in transgene frequency in the wild may reduce insect populations and organisms that rely on them. The high variation of results in studies on gene flow makes it difficult to get a consistent view about their implications for the environment (Van de Wiel, Groot, & den Nijs, 2005).

Wolfenbarger, Naranjo, Lundgren, Bitzer, and Watrud (2008) conducted a meta-analysis on the effects of Bt crops on functional guilds of non-target arthropods. Some species-specific effects have been identified when comparing Bt maize with its unsprayed counterpart; but, when the non-GM counterpart has been controlled with insecticides, Bt maize exhibits a higher abundance of non-target arthropods. The effect of Bt-maize pollen on non-target Lepidoptera in Europe has been estimated to be extremely low, as depicted by the low mortality rates of butterflies and moths reported in the study by Perry et al. (2010). The authors conclude that so far, no negative environmental impact of Cry1Ab-expressing Bt maize has been reported. Álvarez-Alfageme, Bigler, and Romeis (2010) could not reproduce the findings of previous studies reporting harmful effects of Cry1Ab and Cry3Bb on *Adalia bipunctata* larvae feeding on maize, concluding that those studies were most likely based on poor study designs and procedures.

Moving to the human health effects of GM crops, scientific organizations and many authoritative government agencies have concluded that GM foods developed for human consumption are generally safe (EFSA, 2009; FAO/World Health Organization [WHO], 2001; Royal Society, 2002; Society of Toxicology, 2002). Similar conclusions are reported from Bakshi (2003), who reviewed the available literature on potential adverse health effects of GM crops, and Cellini et al. (2004), who examined unintended effects of GM crops and products. To conclude, there is neither a negative impact of Bt maize on environment nor on human health, while the further impact on the environment is positive.

Methodology

Data Collection and Study Area

The aim of this study was to capture the views of Greek farmers towards Bt maize. A survey about the agricultural year 2008-2009 was conducted among maize farmers in July and August 2010 with face-to-face interviews. Farmers were selected by snowball sampling (e.g., Barbieri & Mshenga, 2008; Greig, 2009), a technique where initial study participants recommend additional participants among their colleagues. The snowballing technique was employed due to the high cost of conducting a representative survey with a random sample. Moreover, upon the first contact, some farmers were skeptical about the research because of the topic (i.e., Greece has banned the cultivation of GM crops and recent field trials were subject to vandalism [GMO Compass, 2010a]). The snowball approach (farmers told each other about the study) helped to build trust with farmers. A total of 201 respondents were selected. The study area was the North Eastern region of Greece called East Macedonia and Thrace Periphery. The predominant type of agriculture in the area is arable farming—mainly wheat, maize, and cotton production. East Macedonia and Thrace Periphery had the highest grain maize area planted in the country in 2007, with 67.4 thousand ha, 16,420 maize farmers, and average maize yields of 9.6 t/ha (Eurostat, 2010). Mean pest pressures[6] in East Macedonia and Thrace in 2008 were 58% and 56%, respectively, while the average pest pressure in Greece for the years 2003-2008 was 54% (G. Zanakis, Pioneer Greece, personal communication, October 23, 2012).

In implementing the survey, respondents were briefly informed about the context of the study and told that there are no wrong or right answers, but their opinions were of interest. Data were collected using a formal pre-tested questionnaire. Data collected included farm-level data (e.g., farm size); household characteristics (education, age, income, etc.); and farmers' knowledge, attitudes, and perceptions towards Bt maize. The latter were measured by asking respondents if they strongly agreed or disagreed with 14 statements. The rating of each statement was based on a five-point Likert scale, including 'strongly disagree' (1), 'disagree' (2), 'uncertain' (3), 'agree' (4), and 'strongly agree' (5). These statements were organized in different categories, in particular on knowledge/information about Bt technology (three statements), willingness to adopt Bt maize (five), potential environmental risks (three), and potential health risks (three).[7] See the Appendix for the survey instrument.

Data Analysis

Data analysis was implemented using the statistical package Stata, version 11. The farm and farmer characteristics were analyzed using descriptive statistics. For the attitudinal statements or farmers' perceptions of GM technology, descriptive analysis was initially performed. Next, the statements were subjected to a principal factor analysis with Crawford-Ferguson rotation to reduce the number of variables, reduce the data's complexity, and detect structure in the relationship between variables (i.e., to classify variables). The criteria for acceptability of a factor solution were based on a) minimum factor eigenvalues of 1.0 and b) exclusion of items with factor loadings less than 0.60. A reliability analysis based on Cronbach's alpha statistics was used to investigate the internal consistency of the factors—that is, how closely related a set of items is as a group.

Based on the findings of factor analysis for attitudes towards Bt maize, a non-hierarchical cluster analysis was performed using a K-means cluster analysis. Cluster analysis segments the respondents into groups (i.e., clusters) so that the respondents in the same group are more similar to each other (with respect to attributes of interest) than to those in other groups. To better understand the profiles of the clusters, bivariate analysis using Chi-square tests was applied to relate clusters' mean values with the farmers' socioeconomic characteristics. To explain the cluster membership, a multinomial logit model is estimated using as explanatory variables the farmers' socioeconomic characteristics. The multinomial logit estimates the probability of an individual belonging to a specific cluster. As the estimates of the multinomial logit model are not directly interpretable as meaningful relations, the marginal effects for each explanatory variable were computed. The marginal effect reflects the change in the probability to belong to any cluster given the change in the explanatory variable. Finally, relationships of farmers' socioeconomic characteristics and their perceptions were explored using multivariate regressions. The factors obtained from the factor analysis were used as the dependent variables,

6. *Pest pressure is the percentage of infected corn plants in a region. After selecting a large number of fields in the region of interest, pest-control specialists randomly choose two different rows of 50 continuous plants in each field and count the infected corn plants (by monitoring infection symptoms such as holes in the stalk, broken tassels, etc.). Mean pest pressure is the average (%) of the set of infected corn plants from the fields of a region (G. Zanakis, Pioneer Greece, personal communication, October 23, 2012).*

7. *The statements used in this study were selected after identifying in the GM technology adoption literature the most important factors affecting farmers' adoption of GM crops. Among the important factors affecting GM crops' adoption are prior knowledge (Kolady & Lesser, 2006) and information on the Bt technology (Marra et al., 2001), price variables (Alexander & Van Mellor, 2005), insecticide applications and yield effects (Qaim & de Janvry, 2003), and technological externalities and risks (Breustedt et al., 2008; Kikulwe et al., 2011).*

Table 1. Descriptive statistics of surveyed farmers.

Variable	Category	Mean (Std. dev.)
Age		53.21 (12.24)
Total area planted (ha)		23.60 (21.37)
Maize area planted (ha)		10.84 (11.69)
Agricultural income (all crops in €1.000)		31.02 (37.29)
Non-agricultural income (€1.000)		4.51 (3.39)
	Category	**Proportion of affirmative responses (%)**
Maize use	All sold	75.1
	All farm use	15.4
	Both	9.5
Insecticide use to control corn borers (2008)	Yes	14.4
	No	85.6
Gender	Male	98.5
	Female	1.5
Cooperative member	Yes	74.6
	No	25.4
Education	None	1.5
	Primary	49.7
	Secondary	42.3
	College/univ	6.5

while the explanatory variables included the socioeconomic characteristics of the farmers.

Results

The Respondents

Table 1 provides the summary statistics of the most important socioeconomic characteristics of the surveyed farmers. Male farmers (98.5%) generally responded to the survey questions and the average age of the respondents is 53.2 years. The average farm size is 23.6 ha, of which nearly 10.8 ha is under maize production. Farmers' agricultural and non-agricultural annual income was on average €31,000 and €4,510, respectively. Of all respondents, 75.1% sold all their maize. The majority of the surveyed farmers (around 75%) are members of a cooperative. When comparing our drawn sample with the latest population statistics of Greek farmers, the average farm size in Greece was 4.7 ha in 2007; the average farm size in East Macedonia and Thrace was 6.1 ha (Eurostat, 2010). These statistics show that our sample farm size is much larger than the population mean. Mean income of arable farms in Greece is €25,500 (Eurostat, 2010). Our sample agricultural income is slightly larger than the population mean. Most of the respondents had either attended primary (49.7%) or secondary education (42.3%), while a minority (6.5%) had a university degree. Latest population statistics of all Greek farmers show that 47.7% had primary education, 28.2% secondary education, and 6.5% tertiary education (Hellenic Statistical Authority, 2010). Therefore, the results of this study can be generalized to large Greek producers.

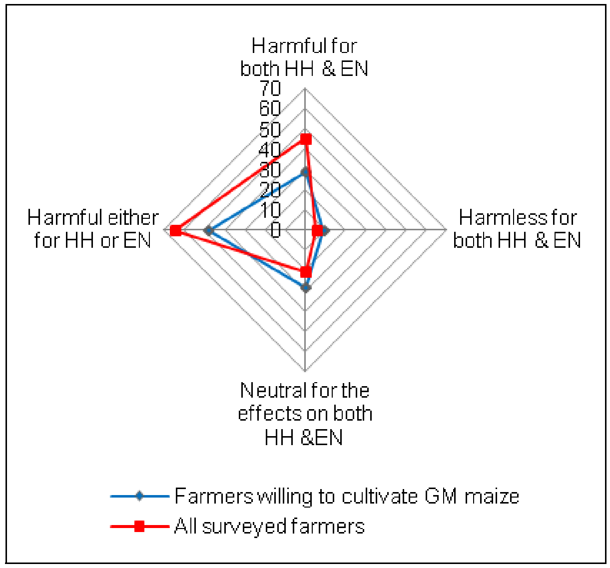

Figure 1. Perceptions of farmers on Bt maize externalities (%).

Note. HH=human health; EN=environment.

Perceptions of GM Technology

Around 94% of the surveyed farmers have heard about Bt maize. Although corn borer was considered to be an important pest in maize cultivation, only 14% of all respondents had used insecticide to control its damage. A descriptive statistic of the Likert-scale part of the survey is presented in the Appendix. Eighty percent of the respondents stated that information on Bt technology is not easily accessible. Around 61% of the questioned farmers would have cultivated Bt maize, 33% answered negatively, and 6% were neutral. Pointing to the benefits of GM maize technology, 56% of the respondents would adopt Bt maize if it was sold at the same price as the conventional one; 68% would adopt Bt maize for the benefit of decreased production costs resulting from the non-use of insecticides for MCB. Only 32% of all respondents and 35% of those that are willing to adopt Bt maize believe that they can effectively control MCB if they use Bt maize, while 57% are neutral. Around

Table 2. Rotated factor loadings.

		Factor loadings		
	Statements	**BtE[1]**	**BtA[2]**	**BtIK[3]**
1	**Information on MON810 is easily accessible.**	-0.032	0.152	**0.706**
2	**I can control more effectively crop damage from the MCB if I cultivate MON810.**	0.313	0.581	-0.067
3	**If the majority of Greek farmers are in favor of MON810 cultivation, it should be legalized.**	-0.310	**0.665**	-0.341
4	**I would have adopted MON810 if its cultivation was legalized.**	-0.304	**0.691**	0.422
5	**I would cultivate MON810 if it was sold at the same price as the conventional.**	-0.221	**0.667**	-0.405
6	**Insecticide use poses a threat to my health and/or the health of my farm employees.**	0.361	-0.100	-0.519
7	**I will cultivate MON810 if I do not have to use insecticides that constitute a considerable production cost.**	-0.144	**0.763**	-0.465
8	**I will cultivate MON810 if I don't have to expose myself or my workers to the health risks of pesticide spraying.**	-0.076	**0.759**	-0.447
9	**Harmful environmental effects of MON810's, and in general GM crops' cultivation, are likely to appear in the future.**	**0.779**	-0.189	0.272
10	**MON810 cultivation can threaten biodiversity.**	**0.771**	-0.273	0.233
11	**Even though GM crops may have advantages, it is basically against nature.**	**0.692**	-0.234	0.263
12	**GM technology should not be used even for medicinal purposes.**	-0.130	0.001	**0.675**
13	**Harmful human health effects of GM foods are likely to appear in the future.**	**0.733**	-0.183	0.409
14	**Even though GM production was distributed exclusively as animal feed, human health might have been still in danger.**	**0.787**	-0.216	0.368

Note: Loadings in bold are values of 0.6 and above. [1] BtE=Bt maize externalities; [2] BtA=Bt maize acceptability; [3] BtIK=Bt maize information-knowledge

91% of the questioned farmers pointed out the use of insecticides pose a threat to the health of the farm operator. As a result, 68% stated that they would adopt Bt maize to avoid exposure to insecticide spraying. On Bt maize's externalities, around 50% and 59% of the surveyed farmers believe that Bt maize cultivation poses a risk to the environment and human health, respectively.

Figure 1 compares the perceptions of all surveyed farmers and those that are keen on adopting Bt maize towards Bt maize's externalities. Only 8.9% of the farmers that are positive towards Bt maize adoption believe that Bt maize does not pose any threat to both human health and the environment, while the percentage drops to 5.4% if we consider all the questioned farmers. From all respondents, around 45% believe that Bt maize poses risks to both human health and the environment, while 29% of the farmers that are interested in cultivating Bt maize share the same opinion. Around 65% and 48% of all surveyed farmers and those that are willing to adopt Bt maize, respectively, stated that Bt maize has negative effects either on human health or the environment.

Factor Analysis

The results of the factor analysis indicate the most appropriate solution involving three factors. An orthogonal Crawford-Ferguson rotation specifying a three-factor solution accounted for 65% of the common variance, which can—in the social sciences—be regarded as satisfactory (Hair et al, 1995). More specifically, Factor 1 accounts for 24%, Factor 2 for 23%, and Factor 3 for 18%; this suggests that each factor represents an important indicator of farmer attitude. Cronbach's alpha statistic was used to examine the internal consistency of the factors, reporting moderate to high values ($\alpha \geq 0.6$) that show the homogeneity of each factor. Table 2 shows the factor loadings of the three factors identified. According to the loadings, the factors can be best described as Bt maize "externalities" (BtE), "acceptability" (BtA), and "information-knowledge" (BtIK). BtE factor has high loadings on statements related to environmental and health risks of the Bt maize cultivation and consumption. Therefore, it refers to farmers' concerns over the impact of Bt maize on human health and the environment. BtA factor has high loadings on questions related to approval of Bt maize cultivation based on its various potential benefits (e.g., more effective control of the

Table 3. Percentage of changes in each cluster.

Cluster names	Percentages
USE (farmers that are unaware of the Bt technology and consider it safe for the environment)	30 (61)
UNSE (farmers that are unaware and do not consider Bt technology as safe for the environment)	18 (36)
ASA (farmers that are aware of and support the adoption of Bt technology)	26 (52)
AOA (farmers that are aware of and oppose its adoption)	26 (52)

Note. Numbers in parenthesis represents the number of respondents.

Table 4. Cluster means for attitudinal statements.

		Clusters				
	Statements	USE	UNSE	ASA	AOA	Full sample
1	Information on MON810 is easily accessible.	1.61	1.47	2.65	2.13	1.99
2	I can control more effectively crop damage from the MCB if I cultivate MON810.	3.3	3.83	3.71	2.77	3.36
3	If the majority of Greek farmers are in favor of MON810 cultivation, it should be legalized.	4.21	3.61	3.73	1.94	3.39
4	I would have adopted MON810 if its cultivation was legalized.	4.7	3.83	3.75	1.67	3.52
5	I would cultivate MON810 if it was sold at the same price as the conventional one.	4.26	3.61	3.67	1.62	3.31
6	Insecticide use poses a threat to my health and/or the health of my farm employees.	4.66	4.92	3.98	4.37	4.45
7	I will cultivate MON810 if I do not have to use insecticides that constitute a considerable production cost.	4.62	4.22	4.08	2.04	3.74
8	I will cultivate MON810 if I don't have to expose myself or my workers to the health risks of pesticide spraying.	4.52	4.31	4.15	2.1	3.76
9	Harmful environmental effects of MON810's, and in general GM crops' cultivation, are likely to appear in the future.	2.64	4.17	3.85	4.04	3.59
10	MON810 cultivation can threaten biodiversity.	2.74	4.28	3.63	4.12	3.6
11	Even though GM crops may have advantages, it is basically against nature.	2.82	4.28	3.87	4.23	3.72
12	GM technology should not be used even for medicinal purposes.	2.75	2.11	3.71	3.46	3.07
13	Harmful human health effects of GM foods are likely to appear in the future.	2.66	4.19	3.98	4.19	3.67
14	Even though GM production was distributed exclusively as animal feed, human health might have been still in danger.	2.48	4.31	3.96	4.27	3.65

pest, no insecticide use). This category captures the tendency of a farmer to cultivate Bt maize. The third factor (BtIK) has high loadings on statements that concern farmers' information on Bt maize. Therefore, it reflects the knowledge status of Greek farmers on Bt maize.

Cluster Analysis

To identify farmer-segment attitudes towards Bt maize, a cluster analysis was run based on the findings of factor analysis. The number of clusters to be generated was identified using the Calinski and Harabasz (1974) pseudo-F index (Calinski stopping rule; Milligan & Cooper, 1985). The pseudo-F index increased as more clusters were added, but was minimized after the fourth cluster. Therefore, four clusters were considered appropriate. Table 3 provides the number and percentage of cases in each cluster: the four clusters carry cluster membership of 30%, 18%, 26%, and 26%, respectively. An ANOVA test was performed to test the validity of the four clusters. A 1% significance level was attained, indicating robust results of classification. To label the four clusters, both the original questions and the results of the factor analysis were used. Table 4 presents the sample and clusters' means based on the raw data of the attitudinal statements. Cluster labeling was not based on individual statements but on differences between group means. Cluster 1 had the lowest score for information on the Bt technology (Statement 1) and low scores for potential environmental/health risks of Bt maize (Statements 9, 10, 11, 13, 14). Thus the following label was

Table 5. Socioeconomic characteristics by cluster.

Variable	Definition	Full sample	USE	UNSE	ASA	AOA
Age	Age in years	53.21	55.05	51.97	52.42	52.71
Education	1=secondary or tertiary education (university or college); 0=no education or attendance of primary education	0.49	0.47	0.53	0.42	0.58
Total area planted	Measured in hectares (ha)	23.60	20.83	21.42	24.50	27.29
Maize area planted	Measured in hectares (ha)	10.84*	14.12*	8.41*	8.34*	11.19*
Cooperative member	1=cooperative member; 0=otherwise	0.75*	0.59*	0.89*	0.83*	0.75*
Maize use	1=maize produce was sold commercially; 0=maize production was used at the farm or one part was used at the farm and the other was sold	0.75	0.69	0.81	0.69	0.83
Insecticide use	1=used insecticides to control corn borers; 0=otherwise	0.14	0.17	0.19	0.11	0.09
Agricultural income	Annual income estimated in Euros (x1000)	31.03	37.52	28.59	27.11	29.02
Non-agricultural income	Annual off-farm income estimated in Euros (x1000)	4.51	9.32	1.91	2.37	4.44

*Note. * significant at the 0.05 level.*

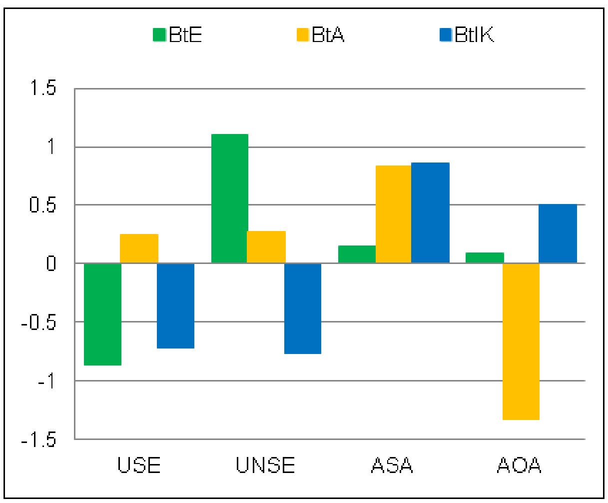

Figure 2. Farmers' cluster membership and mean factor deviations.

preferred: farmers that are unaware of the Bt technology and believe that it is safe for the environment/health (USE). Cluster 2 also scored low on information about the Bt technology (Statement 1), but scores for potential environmental/health risks of Bt maize were high. Therefore, the following name was assigned to this cluster: farmers that are unaware of the technology and believe that it is not safe for the environment (UNSE). Clusters 3 and 4 had high scores for information on the Bt technology, but they differed in Bt adoption statements (Statements 3, 4, 5, 7, 8). Thus, the names preferred for Clusters 3 and 4 were: farmers that are aware of the technology and support its adoption (ASA), and farmers that are aware and oppose its adoption (AOA), respectively.

Figure 2 shows the mean deviation of each cluster from the grand factor mean of the overall sample for the three factors. The first group (31% of respondents) is not aware of the Bt technology but does not believe that it can harm the environment/health. The second cluster is also unaware of Bt technology but thinks that it can harm the environment/health. The members of the first two clusters are slightly positive towards Bt maize adoption. Sixty-one (30.35%) and 36 (17.91%) respondents belong to the first and second cluster, respectively. The third and fourth clusters consist of farmers that are aware of the Bt technology and are in favor and against adopting it, respectively. Each of these two clusters consists of 52 (25.87%) respondents.

Another aspect in which farmers differ among clusters is their socioeconomic characteristics (Table 5). Farmers that perceive Bt maize as unsafe for the environment/health are more often cooperative members, while the group of farmers that does not express any environmental/health concerns contains fewer cooperative members. The number of cooperative members is high, but not significantly different for supporters (ASO) and opponents (AOA) of adopting Bt maize. Farmers that are not highly concerned with Bt maize's environmental/health risks have higher maize area

Table 6. Marginal effects of multinomial logit model explaining cluster membership by socioeconomic characteristics.

Cluster	USE	UNSE	ASA	AOA
Age	0.0072**	-0.0035	-0.0049	0.0011
	(0.0033)	(0.0025)	(0.0035)	(0.0031)
Maize area planted	0.0008*	-0.0005	-0.0005	0.0002
	(0.0003)	(0.0003)	(0.0004)	(0.0003)
Other crops area planted[a]	-0.0001	0.0003*	0.0002	-0.0004***
	(0.0002)	(0.0001)	(0.0002)	(0.0002)
Cooperative member	-0.2355*	0.1442	0.1091	-0.0177
	(0.0623)	(0.0956)	(0.0808)	(0.0724)
Maize use	-0.1241***	0.0906	-0.0386	0.0721
	(0.0688)	(0.0709)	(0.0702)	(0.0874)
Education	0.0433	-0.0293	-0.1252***	0.1112
	(0.0869)	(0.0633)	(0.0716)	(0.0901)
Insecticide use	-0.1351***	-0.0494	0.1093	0.0752
	(0.0763)	(0.0672)	(0.0958)	(0.0917)

Note. Standard errors in parentheses

, **, and * indicate that the estimate is significantly different from zero at the 10%, 5%, and 1% significance level, respectively.*

[a] It represents farmers' non-maize area planted and is computed by subtracting the maize area planted from the farm's total area planted.

planted than all the other groups of farmers. The mean age, education, total area planted, maize, and insecticide use do not show significant differences across clusters. Farmers with higher agricultural and non-agricultural income are more often considering Bt maize as safe for the environment/health compared to the rest of the clusters, but these differences are not significant even at the 10% significance level.

To explain the cluster membership, a multinomial logit regression was estimated, using the GM opponent cluster (AOA) as the reference category. Table 6 reports the marginal effects. Older respondents with larger maize areas planted, who do not belong to cooperative groups, do not sell maize commercially, and do not use insecticides to control corn borers are more likely to belong to the USE cluster. The UNSE members are more likely to have larger land area devoted to other (than maize) crops than the cluster of opponents (AOA). Finally, the ASA cluster members are less likely to be highly educated.

Perceptions in Relation to Farm and Farmer Characteristics

The relationship between farmers' perceptions for Bt technology and their characteristics were analyzed using multivariate regressions. The dependent variables were the three factors obtained from factor analysis (i.e., BtE, BtA, and BtIK), while the independent variables were the farmers' socioeconomic characteristics. Based on a correlation analysis, the variable 'total farm size' was excluded from the estimation, as it was highly correlated with the variables 'agricultural output' and 'maize area planted.' Results of the multivariate analysis are shown in Table 7. On BtE, farmers with higher maize hectarage express less concern about environmental and health risks of Bt maize, while those that sell their maize produced commercially and those who are cooperative members were more concerned about Bt maize externalities. Age, education, and agricultural and non-agricultural income are found to be insignificant. As far as the acceptability of the Bt maize technology (BtA) is concerned, high-income farmers seem to be more eager to cultivate Bt maize than low-income farmers. Education level of the operator has a negative—though statistically insignificant—effect on adoption. For BtIK, being a member of a cooperative provides a better understanding of the new technology. All other variables were not significant at less than 10% significance level.

Discussion

Most of the surveyed farmers stated that information on Bt maize is not easily accessible (Table A1). As Greece has banned the cultivation of GM crops, state agricultural authorities, cooperatives, and seed companies cannot officially inform farmers about GM maize varieties. The ministry of Rural Development and Food has rejected a recent university application for field trials, and earlier illegal field trials were subject to vandalism (GMO Compass, 2010a).

Table 7. Comparison of farmers' perceptions on GM maize technology with farm and farmer characteristics.

	Factors		
Variables	**BtE**	**BtA**	**BtIK**
Age	-0.097 (0.789)	-0.154 (0.683)	-0.297 (0.432)
Maize area planted	-0.214** (0.018)	-0.012 (0.892)	-0.015 (0.867)
Agricultural income	0.028 (0.753)	0.218** (0.020)	-0.077 (0.405)
Non-agricultural income	0.009 (0.717)	-0.013 (0.592)	0.020 (0.437)
Education	0.191 (0.299)	-0.281 (0.139)	-0.010 (0.957)
Cooperative member	0.515* (0.002)	0.093 (0.576)	0.392** (0.021)
Maize use	0.351** (0.036)	-0.033 (0.846)	-0.072 (0.673)

*Note. * and ** indicate that the estimate is significantly different from zero at the 1% and 5% significance level, respectively.*

The low number of farmers that used insecticides to reduce corn borer crop damage is mainly attributed to the lack of access to special spraying machinery (Consmüller, Beckmann, & Schleyer, 2008). The majority of the sampled farmers responded positively (61%) about cultivating Bt maize if the ban is lifted (Table A1). These results are in line with Skevas et al. (2009), who conducted a survey of GM and non-GM maize farmers in Portugal. They found that 50% of the non-GM maize farmers were open to cultivating GM maize, 2% were answered negatively, and 48% were undecided. Similarly, the Polish Federation of Biotechnology (PFB, 2004) has conducted a survey on the knowledge and acceptability of GM crops by Polish farmers and found that 59% of the interviewed farmers would like to have the choice to cultivate GM crops. A more recent farm report from Poland (PFB, 2006), presenting results from GM crops' marketing tests, revealed that 42% and 85% of the respondents agree that GM seeds should be commercially available and farmers should have the right to choose whether to cultivate GM crops, respectively. Interestingly, in a recent study among farmers in Spain, France, and Hungary on the potential adoption of herbicide-tolerant maize, Areal et al. (2011) found a low rate among French (37%) and Hungarian (38%) farmers who agree with their countries' bans on Bt maize and the governments' strong opposition towards GM crops. Our results show that the government's strong opposition towards GM crops is not necessarily reflected by the view of the majority of the farmers.

The economic benefits of GM maize cultivation (increased yield, decreased production cost) are the main drivers behind Greek farmers to adopt the GM technology (Table A1). Gomez-Barbero, Berbel, and Rodriguez-Cerezo (2008) and Skevas et al. (2009) reported the economic benefits of Bt maize cultivation (e.g., higher yields) and the low risk of corn borer damage among the most important reasons for cultivating Bt maize in Spain and Portugal, respectively. Areal et al. (2011) also found that economic aspects are the major reasons for the potential adoption of herbicide-tolerant maize in France, Hungary, and Spain, and herbicide-tolerant oilseed rape in the Czech Republic, Germany, and the United Kingdom. The high number of Greek farmers that expressed their neutrality on the effectiveness of Bt maize in controlling pest damage (Table A1) may be credited to the lack of previous experience in cultivating Bt maize compared to Spanish and Portuguese farmers.

On Bt maize externalities, only a very small number of the farmers that support its cultivation believe that it does not pose any risk to human health and the environment (Figure 1); even so, there are net-environmental benefits linked with Bt-maize production (Wesseler, Scatasta, & Fall, 2011). Lack of previous experience in planting Bt maize, ignorance of the environmental and health safety assessments for approval and cultivation of a GM crop in the EU (EFSA, 2009), and the overall negative attitude of the Greek government towards GM food and crops, may be some of the reasons that explain farmers' concerns about Bt maize externalities. The small percentage of farmers that did not express any concerns about Bt maize risks for human health and the environment contradicts the findings of Skevas et al. (2009) for Portugal; that study reported that almost all GM farmers believe that Bt maize cannot harm human health and the environment. In the same study, few non-GM farmers have referred to Bt maize externalities as a reason for not adopting the technology.

Selling all of the produced crop commercially and being a member of a cooperative tends to increase farmers' awareness of Bt maize risks. Personal or cooperative contracts for selling the produced maize may exist between farmers and food companies. If these food companies have been certified or self-declared as GM-free,[8] this may also affect farmers' opinions toward Bt maize.

As far as the willingness to adopt the GM technology is concerned, high-income farmers are more eager to cultivating Bt maize than low-income farmers. Economic benefits drawn from higher yields, less or no use of pesticides, and more effective control of the MCB damage can drive those farmers to adopt the GM technology. The positive influence of farm profit on GM crops' adoption is also referred by Marra et al. (2001) for Bt cotton adoption in the United States, and Breustedt et al. (2008) for GM oilseed rape adoption in Germany. Marra et al. (2001) reported a positive impact of farmers' education level on GM crops' adoption, which is inconsistent with our results. Weaver (2005) reported a negative influence of education on adoption of transgenic soybean in the United States. This is verified by the cluster analysis employed in this study, which shows that supporters of GM maize adoption are less likely to be highly educated (Table 4).

The results show that a considerable group of farmers (66%) do not oppose GM technology. Arvanitoyannis and Krystallis (2005) show the existence of a similar segment (56%) on the consumer side. Therefore, EU and Greek policymakers should realize that there is not a consensus regarding the rejection of GM crops in Greece. The continuous opposition of GMOs by Greek environmental groups and NGOs is still affecting even experimental GM cultivation (Botetzagias, Boudourides, & Kalamaras, 2004; Marouda-Chatjoulis, Stathopoulou, & Sakellaris, 1998). Also, the previous (2001) directive on the deliberate release of GMOs provided the legal certainty that member states needed to adopt permanent bans (through recourse to the safeguard clause), thus discouraging potential legal challenges from biotechnology companies or other stakeholders. But the renationalization of GM crop cultivation decision-making may weaken the legal position of countries that ban GM crop cultivation. According to the new proposal (IP/10/921), bans on GM crops' cultivation should be based on reasons other than the environmental risks of GM crops and food. Maintaining public order in the face of severe public opposition to the GM technology may be used as a reason for banning GM crops. But this study shows most of the questioned farmers do not oppose GM technology, while evidence from the consumers' side leads to similar conclusions (Arvanitoyannis & Krystallis, 2004).

8. *Greenpeace Greece has published a consumers' guide that classifies Greek food companies according to their intensity in using GM feed in their production process (Greenpeace, 2010).*

Conclusions

In this study, we examined large Greek farmers' acceptability and perceptions toward Bt maize cultivation. Factor analysis was used to reduce the number of variables coming from a Likert-scale-type survey, while a cluster analysis on the identified factors revealed different groups of farmers. Multivariate regression has been applied to get empirical insights into farmers' perceptions of Bt maize and their socioeconomic characteristics. The most interesting finding is that most of the surveyed farmers responded positively to the notion of cultivating Bt maize if Greece lifts the current ban. However, a notable number of all respondents—and those that are positive toward Bt maize adoption—stated that Bt maize could pose a threat to human health and the environment. This is contrary to EFSA's health and environmental assessments and other scientific studies, which show that early concerns about severe negative implications on the environment have not materialized. GM adoption decisions are driven by expectations of decreased production costs due to reduced insecticide use. High agricultural income earners, and not necessarily highly educated farmers, are more likely to adopt Bt maize. Older and specialized maize farmers show a low level of concern about potential environmental safety and potential food safety issues associated with the cultivation of Bt maize. Selling the maize harvest and being a member of a cooperative increases farmers' awareness of the external effects of GM technology. Lack of information about Bt maize increases farmers' uncertainty on the effectiveness of the technology and their negative attitudes towards its environmental and health effects.

Furthermore, GM technology is not opposed by the majority of Greek maize producers. This finding contradicts the results of the recent Eurobarometer (2010) survey by showing that there is no consensus regarding the rejection of GM technology in Greece. The ban alone causes an economic loss of about €12 million per year. Under the current financial crisis, Greece cannot afford to forgo this kind of economic benefit. As EU coexistence policies also require non-discrimination against potential GM farmers, a constructive dialogue with all the involved stakeholders must begin to determine if there is a real demand for GM crops. Further, as the new EU regulations demand the GM bans to be based on reasons other than the environmental and health externalities of GM crops, our results do not support the Greek ban based on the argument that it is supported by the majority of farmers. Future research should investigate farmers' preferences towards GM crops in other EU member states that oppose GM crop cultivation as well. Such research can provide more detailed—local, crop, and trait differentiated—information about farmers' views regarding the technology. This information will be important as the number of GMO-free food products, and farmers involved in their production is increasing in the EU; simultaneously, the number of GM crops worldwide increases. These developments pose new challenges—not only for EU farmers—that need more attention.

Our snowball sampling approach helped to reach a segment of farmers from a hidden population that was less accessible if a probabilistic sampling method was to be applied. However, as noted by many researchers (e.g., Atkinson & Flint, 2001; Kendall et al., 2008), we believe that the data collected through this methodology over-represented the proportion of some segments of Greek maize farmers, especially the USE farmers (segment). Our results are therefore over optimistic. As a result, adjustment towards systematic data collection could significantly improve the current research findings and perhaps our understanding of the general Greek farmers' attitudes toward GMOs.

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See next page for Appendix

Appendix

Table A1. Descriptive statistics of the Likert-scale.

		Proportion of affirmative responses (%)				
	Statements	**Strongly disagree**	**Disagree**	**Neutral**	**Agree**	**Strongly agree**
1	Information on MON810 is easily accessible.	37.31	43.28	4.98	11.94	2.49
2	I can control more effectively crop damage from the MCB if I cultivate MON810.	1.00	8.96	57.71	17.41	14.93
3	If the majority of Greek farmers are in favor of MON810 cultivation, it should be legalized.	10.95	20.40	11.94	31.84	24.88
4	I would have adopted MON810 if its cultivation was legalized.	17.41	15.42	5.97	20.4	40.80
5	I would cultivate MON810 if it was sold at the same price as the conventional one.	17.91	18.41	7.46	27.36	28.86
6	Insecticide use poses a threat to my health and/or the health of my farm employees.	1.00	3.98	3.48	31.84	59.70
7	I will cultivate MON810 if I do not have to use insecticides that constitute a considerable production cost.	6.97	16.92	7.46	32.34	36.32
8	I will cultivate MON810 if I don't have to expose myself or my workers to the health risks of pesticide spraying.	5.47	18.41	7.96	30.85	37.31
9	Harmful environmental effects of MON810's, and in general GM crops' cultivation, are likely to appear in the future.	3.48	6.97	38.81	28.86	21.89
10	MON810 cultivation can threaten biodiversity.	0.50	9.95	38.31	31.34	19.9
11	Even though GM crops may have advantages, it is basically against nature.	3.98	8.96	22.89	39.80	24.38
12	GM technology should not be used even for medicinal purposes.	10.95	10.45	48.76	20.40	9.45
13	Harmful human health effects of GM foods are likely to appear in the future.	2.49	11.44	26.87	34.83	24.38
14	Even though GM production was distributed exclusively as animal feed, human health might have been still in danger.	4.98	10.95	26.37	29.35	28.36