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Farmer Acceptance of Genetically Modified Seeds in Germany: Results of a Cluster Analysis

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Abstract

Discussion on plant genetic engineering has experienced increasing momentum with the introduction of Genetically Modified (GM) corn in Germany and other European countries. This paper determines the various groups of German farmers, their attitudes and expected decisions on the use of GM foods using cluster analysis of 370 German farm managers. The results of cluster analysis indicate five main farmer groups who differ in terms of certain demographic characteristics and attitudes towards GM adoption. The study proposes tailored communication and risk management as an important measure that can be used by the biotechnology advocates to improve the level of acceptance.

Keywords: Biotechnology, cluster analysis, German farmers

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Introduction

Acceptance of Genetically Modified (GM) food remains a critical factor that will affect the future growth of agricultural biotechnology (BT). Plant genetic engineering has received more intense discussion than almost every other topic in agriculture. In many countries, the debate on GM revolves around the risks and the benefits of biotechnology in the production of food and feed (Isserman, 2001). Onyango et al., (2004) observe that the discussion on plant genetic engineering has split the public into two. On one side of the debate are the supporters of biotechnology who emphasize its importance to mankind in the form of improved supply of food, feed, and medicine, as well as reduction in insecticide and labour cost which provide economic benefits to the adopters (Isserman, 2001; Gianessi et al., 2002; Payne et al., 2003; Sankular et al., 2005). Brookes and Barfoot (2006) estimate the increase in income for farmers who adopted GM to about $27 billion worldwide for the year 2005. On the other side are the opponents who argue that plant genetic engineering is an interference of nature and may have unknown and disastrous consequences (Nelson, 2001). People on this side have further strengthened their position by arguing that GM may have the tendency to contaminate the non-GM product, such as organic food through processes like pollination.

In Europe, the cultivation of GM-seeds has no meaningful significance. Commercially, only genetically modified BT-Corn is cultivated on few arable lands. This may be attributed to different reasons such as the genetic moratorium of the European Union of 1998 to 2003 and the current law on genetic engineering, which are disingenuous to the cultivation of GM seeds. As the commercial use of plant genetic engineering in Europe is just at its beginning, there are only a few studies that explain the influence of the adoption of the biotechnology by farmers. Until now, the research has almost exclusively concentrated on consumers (e.g. O'Connor et al., 2005; Miles et al., 2005), nearly neglecting the position of farmers in Europe (Breustedt, 2008).

This paper fills this lacuna in the agribusiness literature. We contribute to the discourse on biotechnology in agriculture in two main ways. First, unlike previous studies, which predominantly analyse the GM acceptance from the perspective of the consumers, we take the perspective of producers and analyze the behavioral patterns of German farmers towards plant genetic engineering. Second, we segment the farmers into various groups based on their attitudes and opinions towards genetic engineering.

Our analysis is based on the stated as opposed to actual adoption of GM. This is because biotechnology is still not in commercial quantities in Germany, and as such the farmers' expectation of the likelihood of adoption will be based on information that is obtained from many sources including the media, popular magazines, and public sources.

The remaining sections of the article are organized as follows: the next section provides background information about biotechnology in agriculture in Germany. Following, we present a brief overview of the research on biotechnology in agriculture and present the technology acceptance model by Voss et al. (2008), which will be used as the basis for classifying the farmers. Methodology of the study will be presented in the next section. Cluster solutions and their implications are then discussed and, subsequently, we highlight the limitations of the study and propose direction for future research.

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Overview of Biotechnology Research in Agriculture

For the purpose of this paper, terms such as genetic engineering, biotechnology, biologically engineered, and genetically modified will be used synonymously to represent a set of technologies that are used to change the genetic makeup of cells and move genes across species' boundaries to produce novel organisms. This may involve highly sophisticated manipulations of genetic materials and other biologically important chemicals. By altering a plant's trait, genetic engineering facilitates development of characteristics not possible through traditional plant breeding techniques (Fernandez-Cornejo et al., 2002).

Recently, scientific studies on the agricultural adoption of plant genetic engineering have noticeably increased. As a consequence, there is a growing subset of the technology adoption literature that specifically examines the adoption of GM crops (Alexander et al., 2003; Fernandez-Cornejo et al., 2002; Payne et al., 2003).

There are two main research streams on the GM adoption in the food supply chain literature. One stream concentrates on the demand side and measures the level of acceptance or adoption from the perspective of consumers, retailers, processors, and other stakeholders (e.g., Frewer et al., 1995; Saba and Vassallo, 2002; Fortin and Renton, 2003; Onyango et al., 2004; O'Connor et al., 2005). The second stream concentrates on GM adoption from the supply side, which involves adoption by farmers measured in terms of both their revealed and stated preferences (e.g., Van Scharrel, 2003; Payne et al., 2003; Merrill et al., 2005; Voss et al., 2009).

Breustedt et al. (2008) divided the analyses of biotechnology adoption in agriculture into *ex post* and *ex ante* studies. The *ex post* refers to the case where the GM has been launched already. In this situation, it becomes possible for the researchers to conduct their analyses based on information collected on the actual behaviour of the farmers, referred to as the revealed preference approach. The *ex ante* analyses are conducted in a situation where expected behavior of the farmers is determined using methods such as the contingent valuation. This is often referred to as the stated preference. The most common factors that have been analyzed in the adoption literature are expected profitability, risk, required skill level or education, scale or size of farm, alternative or competing technologies, credit availability, and environmental policies (Sundig and Zilberman, 2001).

Hubbell et al. (2000) and Qaim and de Javry (2003), for instance, analyzed the dichotomous choice between adoption and non-adoption of BT cotton in the U.S. and Argentina based on revealed and stated preferences. In both studies, the authors observed that the level of education and farm size relate positively with the likelihood of adoption. Corinne et al. (2005) analyzed the adoption of transgenic corn resistant to corn rootworm (CRW corn) using a probit model with data from Indiana farmers. Their analysis revealed that operator age, farm size, regional, and self-reported measures of rootworm pressure were all statistically significant in explaining the level of adoption by the farmers.

Kolady and Lesser (2006) and Krishna and Qaim (2007) conducted *ex ante* analyses of genetically engineered eggplant adoption in India using varieties of choice-based experiments. Kolady and Lesser (2006) observed that a higher price of BT seed reduces the probability of

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adoption in the early years after the launch of the BT varieties, but has no significant influence after it has been launched.

Qaim and de Javry (2003), using a double bounded dichotomous choice model in their experiment, found that the average Willingness to Pay (WTP) for BT eggplants is more than four times the current price of non-BT hybrids.

The situation for BT-seed adoption in Europe is a bit different compared to the U.S. and many developing countries. This is especially significant against the background that many Europeans are more skeptical about the use of BT compared to users in other parts of the world. Their reasons emanate from both ecological and ethical perspectives. In addition, the co-existence law with strong liability rules such as the "adventitous" (Weber et al., 2007) present further burden to the farmers who might want to adopt BT seeds in their farms.

These notwithstanding, there have been recent, although few studies on biotechnology in agriculture from the perspective of European farmers. In a study by Gomez-Barbero et al. (2008), the authors observed an increase in the level of average yield of farmers who adopted transgenic BT corn compared to the non-adopters in Spain for the three growing seasons spanning the years 2002-2004. This further resulted in an increase in the economic benefits for the adopters since no price premium was obtained for the cultivation of the conventional corn. Breustedt et al. (2008) explored the German farmers' willingness to adopt a GM oil-seed rape prior to its commercial release, and estimated the demand for the new technology based on 202 German farmers. Using the multinomial probit estimation, the authors revealed that GM attributes such as gross margin, expected liability from cross pollination, flexibility to return to conventional oil seed, and some farm characteristics significantly affect the likelihood of adoption.

Until now, choice analysis and contingent valuation methods exploring influencing factors in farmers' adoption of BT dominate the agribusiness literature. To the best of our knowledge, none of the studies considered how the farmers can be grouped and characterized based on their attitudes towards the adoption of GM food, especially in the context of Germany. This is particularly important as it will provide a basis for policy makers, the biotechnology industry, and other interest groups to be able to develop a specialized approach and strategy in an effort to address issues on BT adoption since it has been found to provide economic benefits to the adopters. Our research, therefore, provides a new approach to the analysis of farmer acceptance of biotechnology by providing a cluster analysis of German farmers based on the technology acceptance model.

The Technology Acceptance Model

In this section, we provide explanation of the technology acceptance model based on the study by Voss et al.(2009). In this model, Voss et al. (2009) used an exploratory factor analysis to identify sets of factors that influence technology acceptance based on interviews with German farm managers. The model identifies four main constructs that influence farmers' attitude toward GM foods. The factors identified by Voss et al. (2009) confirm and synthesize results of many other GM adoption studies such as by Alexander et al. (2003); Alexander and Mellor (2005);

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Darr and Chern (2002); Fernandez-Cornejo et al. (2002) and Merrill et al. (2003), and many other studies as discussed in the preceding section. The factors are manageability of GM seeds, cost effectiveness, acceptance by social environment, and pressure from industry.

The manageability of GM seeds factor concerns the handling of GM seeds, and was identified as the most important factor for the explanation of the attitude towards plant genetic engineering. The model postulates an inverse relationship between the ease with which GM seeds can be handled and their usage rate. This implies that the smaller and the more difficult the handling of plant genetic engineering seed is estimated to be, the higher the negative attitude towards plant genetic engineering. The construct 'handling' combines statements from the use of GM crop yield, as well as for the realization of co-existence with conventional seeds. The second most important explanatory variable, which was identified by Voss et al. (2009), is the acceptance by the social environment. This factor deals with how farmers' decision to use GM seeds are influenced by their social factors such as family, community, and friends.

The cost effectiveness was identified as the third most important decision factor and concerns the estimation of the cost effectiveness of GM seeds. This factor assumes that the cost of GM is taken into consideration by farmers in their decision on whether or not to adopt. It postulates a negative relationship between cost and usage rate indicating that when the cost of usage is low, more farmers are likely to adopt and vice versa. Pressure from industry was the least most important factor and relates to how the industry influences farmers' adoption of GM. The items used by Voss et al. (2009) seem to indicate aspects including pressure from structural changes in agriculture, the usefulness of GM seeds, as well as the influence of GM on agricultural effectiveness.

According to the model, farmers' attitudes toward the GM food is exhibited by their action or intention to use, which is influenced directly by the social environment and pressure from the industry. The manageability of GM seeds, the cost effectiveness, and the acceptance by the social environment influence the action indirectly through their attitudes towards the GM seed.

Methodology

Study-design and operationalization of the constructs

In May and June of 2006, 202 German farm managers in the north-west of Germany were interviewed concerning their attitudes and opinions toward GM seeds by means of personal interviews. The sample selected is a convenient sample with focus on business and future oriented farms, which are considered as the most important customers of the seed industry. The interviewers approached the subjects and briefly explained the purpose of the study and requested their participation.

The interviews were subdivided into two parts: the first section was concerned with the collection of data on general attitudes towards GM seeds, as well as the demographic characteristics of the respondents. The second section was conducted by selecting a case study in order to obtain indepth knowledge on issues concerning GM acceptance. Depending on the cultivation centre, a case study with the Roundup-Ready sugar beet or with BT Corn was

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presented. The questions related to acceptance probability of GM seeds based on various aspects of the technology acceptance model by Voss et al. (2009).

We operationalized the technology acceptance model by using the statements used by Voss et al. (2009). The acceptance environment was operationalized with three statements made up of how GM is accepted by immediate family, as well as local community. Two statements, which represent the relationship between acceptance as well as peer influence and future development of agriculture, were used to operationalize the pressure from industry construct. Manageability of the GM seed and the cost effectiveness factors were operationalized with four and two statements, respectively.

In addition, three other factors were included in the analysis in order to further describe the clusters. The factors are the general attitude towards GM seed, which was operationalized with eight statements. The level of informedness and the willingness to take risk of the respondents were operationalized with four and and three items, respectively.

In all cases, a five point Likert scale type set of questions, in which the respondents were asked to rate their level of agreement or disagreement with a set of statements, were utilised.

Statistical Analysis

The empirical analyses were done in multiple phases. In the first step, descriptive statistics were conducted using the SPSS statistical package to describe the demographic characteristics of the sample. In the next step, the principal component analysis with varimax rotation was carried out in order to summarize the variables that were used to operationalize the technology acceptance model of Voss et al. (2009). The measurement scale of the factors were purified by calculating the reliability test using the Cronbach Alpha Test (Gyau and Spiller, 2007). The results of the Principal Component Analysis (PCA) and the reliability test are shown in Table 2.

In the next stage of the statistical analysis, standardized factor scores based on the PCA were subjected to a two-stage cluster analysis. The goal of the cluster analysis is to establish groups so that they are internally as homogenous as possible and externally (that is in comparison to each other) preferably heterogenous (Backhaus et al., 2003). An important question is how many clusters are to be used. This is especially relevant against the background that by increasing the number of clusters, we reduce the dissimilarity within each cluster, but at the expense of a description of the data, which has more degrees of freedom and is, therefore, less parsimonious (Gough amd Sazou, 2005). The question of the optimal number of clusters to use remains an active research topic (Sugar and James, 2003).

For this study, we admit that there is not likely to be an absolute, correct number of clusters. This still leaves the question of how many clusters might be sensible to use. Using the standard form of the statistical package SPSS, we carried out a hierarchical cluster analysis. By examining the dendrogram from the hierarchical cluster analysis, scree test, and plausibility considerations, we identified the optimal number of clusters. This number of clusters was then fed into the k-means cluster analysis to obtain the final cluster solution.

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Finally, the Chi-Square Test of Association and Analysis of Variance (ANOVA) were used to determine if there were differences among the clusters. The demographic characteristics, level of informedness, and the psychometric variables concerning attitudes and opinions towards the use of GM were compared among the five clusters in order to further characterize the farmers.

Results

Description of the sample

The structural features of the farms, shown in Table 1, indicate clearly that the sample is not representative. The average farm size of 244.3 hectares in the sample is considerably larger than the national average, which is estimated to be about 30.3 hectares (BMELF, 1998). The average age of farm managers indicates that younger farmers are clearly overrepresented in the controlled sample. The same is to be said for farm managers with an academic education. There are 30.5% of survey participants that have completed an agricultural University degree, which is also considerably higher than the national average of 5.6%.

Table 1. Characteristics of the Sample Farms

Demographic variable **Age of farm manager (years)**	**Number in sample**	**Percentage**
up to 25	29	9.6
26-35	65	21.6
36-45	56	18.8
46-55	95	31.6
56-65	52	17.3
older than 65	4	1.3
Farm size (hectares)		
up to 20	7	2.3
21-50	36	11.7
51-100	109	35.5
101-200	88	28.7
more than 200	67	21.8
Educational level of farm managers		
No agricultural education	13	4.2
Agricultural vocational training	6	1.9
Professional training in agriculture	29	9.3
Agricultural technical school	33	10.6
Further training in agriculture as master farmer	92	29.6
Agricultural college	43	13.8
University degree in agriculture	95	30.5

Factor Analysis of Clustering Variables

In the next stage of the analysis, PCA was conducted using varimax rotation. The factor loadings from the PCA are displayed in Table 2. The factors confirm the dimensions of the technology acceptance model as implemented in Voss et al. (2009). Together, these factors accounted for about 73% of the error variance.

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Table 2. Factor Analysis of Cluster Forming Factors

Explained Variance: 72.6 %, KMO: 0.70	FL
Factor 1 "Acceptance Environment," Cronbach Alpha: 0.70	
The use of GM seeds is accepted in my family	0.719
My village community would accept the cultivation of GM seeds	0.851
My local environment would accept the use of GM seeds	0.809
Factor 2 "Pressure from the industry," Cronbach Alpha: 0.63	
The use of GM seeds will become a matter of course with my colleagues	0.828
Structural change in agriculture will make the use of BT corn indispensable	0.828
Factor 3 "Manageability," Cronbach Alpha: 0.65	
Crop yields from GM seeds are suited for feedstuffs	0.718
I am of the opinion that the use of crop yields derived from GM seeds is unproblematic as far as the production of energy is concerned	0.803
I am of the opinion that a co-existence of GM seeds and conventional seeds is possible	0.773
Semantic differential: useful vs. superfluous	0.526
Factor 4 "Cost effectiveness," Cronbach Alpha: 0.69	
GM seeds are advantageous from an economic point of view	0.852
Working efficiency in agriculture will be improved by the use of GM seeds.	0.852

FL= Factor Loading.

Cluster Analysis of the Respondents

By applying cluster analysis to the standardised factor scores obtained from the PCA analysis as shown in Table 2, five groups were obtained based on their similarities on their perception on the GM foods. The mean and the standard deviation of the standardized factor scores and the number of respondents in each cluster are reported in Table 3 (see Appendix 1). The results of the F test were significant among the various clusters indicating that the clusters are as homogenous within and heterogenous among the clusters. In order to further characterize the clusters, three main factors which cover the general attitude and opinions toward the use of GM seeds, risk and level of informedness about GM foods were used. The results on the three additional factors, which were not used in clustering the variables, are shown in Table 4 (see Appendix 2).

Description of Clusters

By examining the responses of the respondents on the four variables that were used for classification as depicted in Table 3, five clusters were obtained:

Cluster 1 (Supporters)**:** There are 117 respondents in cluster 1, which constitutes about 37% of the sample. This is the cluster with the greatest number of farmers. The farm managers in cluster 1 seem to have no problems with their family and social environment on the use of GM. They showed a positive response on all questions relating to family and social environment. Members of this cluster generally have a positive feeling about the cost effectiveness of GM seeds and believe that the use of GM will lead to improvement in the efficiency of their agricultural activities. They have the strongest belief that GM is good for the production of energy and can

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co-exist with conventional products without problems. Their responses generally seem to have a good impression about the use of GM seeds, and hence are labelled as “GM Supporters.”

Cluster 2 (Economic Skeptics): There are 42 respondents in this cluster made up of 13.5% of the total respondents. The farm managers in this group indicated that their village and local environment will not accept the GM foods although their immediate families support the use of GM weakly. They generally believe that GM will be unproblematic for the production of energy and can co-exist with conventional seeds. This group of respondents do not see the economic advantages of the use of GM seeds as they objected mildly to the two statements that project the economic benefits of GM. However, their degree of objection is not as high as that of the members in cluster 5. Based on their objection to the two statements on the economic benefits of GM, they are labelled as “Economic Skeptics.”

Cluster 3 (Environmentally and Socially Influenced): Farm managers in this cluster are made up of about 30% of the respondents. They generally provide a negative response on all the statements concerning how the use of GM seeds will be accepted by their families. In addition, this group of farm managers objects that GM seeds will be indispensable with structural changes in agriculture. They also object that the use of GM will be accepted by their colleagues. Despite these negative attitudes towards the GM seeds, these farm managers are of the opinion that GM seeds will be advantageous economically and that the efficiency and effectiveness of farm operations can be enhanced with the use of GM seeds. This group is referred to as “Environmentally and Socially Influenced.”

Cluster 4 (Die-hards)**:** The total number of farmers in this group is 59. The farm managers who are in this cluster are referred to as “GM Die-hards” because they seem to show a very strong support to the GM seeds compared to the normal supporters in cluster 1. The managers did not have any problems with their village or community on the use of the GM, as they provided positive responses on all questions on family acceptance. These managers admit that their colleagues will also not have problems with them if they decide to use the GM seeds in their farms and show a very strong acceptance of the statement that GM seeds will become indispensable with the structural changes in agriculture. The respondents in this cluster showed the strongest conviction that the GM seeds will yield economic benefits and enhance work effectiveness when it is used in the farms. They believe that GM can be combined with conventional crops without problems. Based on their strong support for GM, they are referred to as “Die-hards.”

Cluster 5 (Strong Opponents): *There were* 28 people who constitute about 5% of the total respondents grouped in this cluster. They constitute the smallest group in the sample. These managers were regarded as the strongest opponents to the introduction of the GM seeds as most of their responses seem to be opposite of those in cluster 4. They indicated a strong objection to the use of GM seeds to be acceptable by their family and local environment. They do not see structural changes in agriculture to be a cause for the use of GM seeds and have the strongest rejection of the economic advantages of the use of biotechnology seeds. The respondents in this cluster do not think the combination of GM and conventional seeds is a possible option.

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Evaluation of the Clusters

In order to further characterize the clusters and to design appropriate strategies to deal with their attitudes towards GM seeds, they were evaluated based on three main factors which are considered as important to influence farmers' acceptance of GM. These factors are the level of informedness, willingness to take risks, as well as their general opinions towards the use of GM seeds as shown in Table 4 (See Appendix 2). The results for the various variables, as displayed in Table 4, are discussed in turn.

Level of Informedness

By examining the responses of the various groups, it can be observed that the respondents in cluster 4 are the most informed about the current development in the field of GM. Both the Economic Skeptics and the Strong Opponents are marginally informed. The Environmentally and Socially Influenced group, as well as the GM Supporters, object to the statement that they are well informed about the development in the GM field although the strongest objection comes from the former. All the respondents in the various clusters seem to know about the arguments that are put forward by the GM activists with the strongest knowledge coming from the GM Die-hards and the Strong Opponents. The above seems to suggest a relationship between how strong a farmer will either be for or against GM on the one hand and their knowledge of the various arguments that are put forward by the GM promoters on the other hand. All the various groups did not agree to the statements that "I have been able to make a comprehensive overview over GM seeds," except the Strong Opponents and the Die-hards, implying that those at the extreme ends have analyzed the information on the GM. While all the rest object that they have been able to obtain a detailed picture of GM seeds, the Die-hards and the Strong Opponents agree to the assertion.

Willingness to Take Risk

The ability and willingness to take risk may influence the extent of GM adoption. All the farmers in the various clusters seem to base their decision on the economic benefits that may be associated with the adoption of biotechnology. The strongest agreement to the statement which links the use of biotechnology to the economic benefits is observed from the GM Die-hards followed by the Economic Skeptics. The Strong Opponents showed the least agreement to the statement that, "With me, the decision for the adoption of biotechnology is mainly dependent on the economic benefits."

The GM Die-hards and the Supporters are, respectively, the first and second most willing to take higher risks for greater success in their farms. The Strong Opponents are the least willing to take risks, indicating that those people are risk averse and would always stick to their positions even if that means accepting less income. Thus, the Strong Opponents put their personal principles above economic benefits.

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General AttitudesTowards GM

The statements on general attitude towards plant genetic engineering shows that many farmers do not have a clear opinion on the discussion. This implies that the idea that majority of German farmers are against genetic engineering is not confirmed in this study. The farmers in clusters 1 and 4 object to all the negative aspects of GM as used in the general attitudes. Thus, the GM Supporters and the Die-hards generally object to the termination of GM campaigns as well as the continuation of GM protest. Their responses are in sharp contrast to the responses provided by the farmers in cluster 5 who seem to support all the negative statements about GM.

The Economic Skeptics and the Environmentally and Socially Skeptics have a mixed reaction concerning their general attitudes on GM. Managers in both groups object that the protest against GM has to be stopped. Both also object that the implementation of GM must be stopped in Germany. Thus, in general, farmers in both groups do not have a very strong negative attitude or strong support toward GM engineering compared to the supporters and the opponents. Thus, the managers in clusters 2 and 3 are somewhere in between the opponents and the supporters.

Relationship between the Demographic Characteristics and Group Membership

In the next stage of the analysis, we determined how the clusters differ in terms of the demographic characteristics of the participants.

The results of the cluster analysis distinguish between five main farmer groups, which do not differ significantly in terms of farm size and age of the farmers. This implies that whether someone opposes or supports the use of GM is not determined by the age of that person. Thus, farmers of all ages can belong to any of the five clusters identified. This contradicts the study by earlier researchers, such as Alexander and Mellor (2005), who observed that farm sizes were significant in explaining the level of adoption of a transgenic seed that is resistant to the corn rootworm, with younger farmers, showing a higher probability of adoption. A study by Breustedt et al. (2008) also indicates that the age of farmers is also an important variable that influences the level of adoption. The difference in the age variable between our study and the previous ones such as Breustedt et al. (2008) may result from the fact that young farmers were overrepresented in our sample, and hence, the opinion might represent that of young farmers, which may not differ so significantly.

The size of the farms differ significantly among the clusters with cluster 5 differing significantly from the rest. This might suggest that, in general, small-scaled producers are more likely to oppose the use of GM seeds. This supports the results of an earlier work by Alexander and Mellor (2005).

In addition, the level of education is found to have a significant influence on which cluster a farmer belongs. It can be observed that most of the farmers who support the use of GM seeds (Supporters and the Die-hards) constitute a very large percentage of those with high levels of education. The Die-hards and the Supporters represent almost 40% and 35%, respectively of their respective clusters, indicating that farmers with high education are more likely to accept

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biotechnology. Only 33% of the Strong Opponents have a college education or University degree. The farmers who belong to this cluster have the least percentage of combined University, College, and degree-level education. The close connection of education and use of plant genetic engineering was also confirmed by the study from Breustedt et al. (2008).

Table 5: Company Structure of the Clusters

	Cluster 1 n=117 / 37.6%		Cluster 2 n=42 / 13.5%		Cluster 3 n=65 / 20.9%		Cluster 4 n=59 / 19.0%		Cluster 5 n=28 / 9.0%		F-Stat
	μ	σ	μ	σ	μ	σ	μ	σ	μ	σ	
Age	41.6	12.4	45.6	10.5	43.5	12.5	44.6	13.5	45.6	10.9	1.30
Farm size (hectares)	217.8	427.9	315,6	763.6	254.4	629.5	296.4	500.8	123.6	99.6	3.74

Table 6: Company Structure of the Clusters

	Cluster 1 n=117 / 37.6%	Cluster 2 n=42 / 13.5%	Cluster 3 n=65 / 20.9%	Cluster 4 n=59 / 19.0%	Cluster 5 n=28 / 9.0%	F-Stat
No agricultural education at all	4.3%	2.4%	6.3%	3.4%	3.7%	0,273
Agricultural technical school	1.7%	4.8%	0.0%	1.7%	3.7%	0,870
Agricultural vocational training	6.8%	7.1%	17.2%	10.3%	3.7%	1,708
Technical training in Agriculture	9.4%	21.4%	7.8%	10.3%	7.4%	1,538
Further education as master farmer	28.2%	26.2%	32.8%	19.0%	48.1%	2,100
Agricultural college	14.5%	9.5%	14.1%	15.5%	14.8%	0,211
University diploma	35.0%	28.6%	21.9%	39.7%	18.5%	1,895

Conclusion and Implications

In the foregoing analysis, we identified and characterised the various groups of German farm managers concerning their perception of GM acceptance based on the technology acceptance model by Voss et al. (2009). Five main groups of farmers were identified and their behaviour level of informedness about biotechnology in agriculture, willingness to take risks, general attitude towards biotechnology, and their demographic characteristics were determined. The study revealed that the farmer groups differ significantly on their general attitude towards GM acceptance, as well as the level of education and informedness. The differences in the various characteristics and attitudes among the various groups of farmers suggest that differentiated and specifically designed strategies need to be adopted by the relevant stakeholders in the promotion of GM.

For instance, it is suggested that the use of tailored information could be used as a tool by the biotechnology advocates to improve the level of acceptance by the German farmers. Since the respondents in clusters 2 and 3 have indicated that they are only marginally informed about the various aspects of biotechnology in agriculture, stakeholders who see the promotion of

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biotechnology as important for agricultural development through improvement in productivity and farm income can enhance their course by designing information and educational programs according to the specific characteristics of the clusters. As an example, respondents in cluster 2 can be educated and informed about the potential economic benefits of the GM seed. Once they are able to realize the economic benefits that GM can provide, they are more likely to transform from being Skeptics to Supporters and Die-hards. A recent study of BT corn adoption in Spain by Gomez Barbero et al. (2008) published in *Nature Biotechnology* in the year 2008 revealed that Spanish farmers who adopted BT corn had higher economic benefits compared to the non-adopters as a result of increase in yield of the BT corn over the conventional corn. In addition, it was observed in the study that no price premium was obtained for the conventional corn over the BT variety. In addition, respondents in cluster 3 could also be enlightened on the negative campaigns that have been going around about the potential impact of GM seeds by its strong opponents.

While it is admitted generally that provision of information is expected to influence attitudes, Frewer et al. (1995) advocate that the social context in which the information is disseminated is also important to determine the public reactions to that information. This therefore suggests the need for credible, trusted and regulated information sources in order to enhance acceptability (Dittus and Hilliers, 1993; Slovic, 1993). Frewer et al. (1995) argue that the use of proactive information provision by industry and government and the development of effective communication strategies such as the use of "consensus conference approach" can facilitate trust in the information provided through improvement in dialogue among the interest groups. In addition, the media could also be tasked to provide more information on the biotechnology since the media is one major source of such information to the general public. Quality press, television documentaries, and news broadcasts are an important source of trusted information to the general public compared to government and industry sources Frewer et al. (1995).

In addition, since it is observed that the Strong Opponents and the Economic Skeptics also show the strongest belief that the use of GM is associated with risk, some form of risk management tools may be instituted in order to influence the rate of adoption by the German farmers. Fernandez-Cornejo and McBride (2002) have argued that market and production risks faced by producers can be reduced through measures such as contracting, integration, hedging, and time sequencing transactions. Insurance can be instituted for those who would like to transform from the use of non-GM seeds to GM on their farms. These measures can alleviate some of the fears in terms of economic loss about which opponents and the skeptics are concerned. Perry et al. (1977), and Bender and Hill (2000) observed an increase in contracting among growers of GM corn and soybeans as a means to assure producers of market in many countries. Finally, since the Strong Opponents have shown that they are well informed about the arguments, which are put forward by the supporters, we recommend that the biotechnology activists would have to redefine their campaign messages and arguments that are used to defend the use of biotechnology. Thus, their present message might not have gone well with some sections of the population, especially the managers in cluster 5. It is expected that a well defined and efficiently disseminated message may transform the skeptics if not the opponents to accept the use of GM seeds.

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Limitations and Future Research

Like many other studies, this study has some limitations that should be taken into account in the interpretation of the results. The unrepresentativeness of the sample used may limit the interpretation of the results. Future research should, therefore, use a more representative sample and replicate the studies in order to confirm our findings. In addition, our research has only considered the adoption from the perspective of German farmers neglecting other actors in the food supply chain such as the food service and the food processing industries. Future research should, therefore, extend the willingness to accept studies by including other actors in the food chains in order to provide a more holistic view of the entire supply chain.

Finally, the theoretical constructs that were used to cluster the managers lack normative variables such as ethical and religious issues that may influence managers' decisions whether to adopt or not. Future research should, therefore, elaborate on the model that was used for segmenting the managers by explicitly including more normative variables.

References

Alexander, C., Fernandez-Cornejo, J and R.E. Goodhue. 2003. Effects of the GM controversy on Iowa corn-soybean farmers' Acreage Allocation Decisions. *Journal of Agricultural and Resource Economics* 28 (3): 580–595.

Alexander, C. E., and T.V. Mellor. 2005. Determinants of corn rootworm resistant corn adoption in Indiana. *AgBioForum* 8 (4): 197–204.

Backhaus, K., B. Erichson, W. Plinke, and R. Weiber. 2003. Multivariate Analysemethoden: eine anwendungsorientierte Einführung; 11., überarbeite Auflage, Berlin et al.

Bender, K., and L. Hill. 2000. Producer alternatives in growing specialty corn and soybeans. Department of Agricultural and Consumer Economics, University of Illinois, AE-4732.

BMELF 1998 Bekanntmachung der Leitlinien für ein Programm zur Reduzierung des Eintrags von Salmonellen durch Schlachtschweine in der Fleischgewinnung. Bundesanzeiger No. 44/98, 5.3.98, p. 2905.

Breustedt, G., J. Müller-Scheeßel, and H. Meyer-Schatz. 2008. Forecasting the adoption of GM oilseed rape: Evidence from a discrete choice experiment in Germany. *Journal of Agricultural Economics* 59(2): 237-256.

Brookes, G. and P. Barfoot. 2006. GM Crops: The First Ten Years - Global Socio-Economic and Environmental Impacts. ISAAA Brief No. 36. Ithaca, NY.

Darr, D. A. and W.S. Chern. 2002. Analysis of genetically modified organism adoption by Ohio grain farmers. 6th International ICABR Conference on Agricultural Biotechnology in Ravello (Italy).

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Dittus, K.L. and V.N. Hilliers. 1993. Consumer trust and behavior related to pesticides. *Food Technology* July: 87-109.

Fernandez-Cornejo, J., C. Alexander and R.E. Goodhue. 2002. Dynamic Diffusion with Disadoption: The Case of Crop Biotechnology in the USA. *Agricultural and Resource Economics Review* 31(1): 112–116.

Fernandez-Cornejo, J., and W.D. McBride. 2002. Adoption of Bioengineered Crops. United States Department of Agriculture, Economic Research Service. Agricultural Economics Report Number 810, Washington D.C. USA, 2002.

Frewer, L.J., C.Howard and R. Sheperd. 1995. Genetic engineering and food: what determines consumer acceptance. *British Food Journal* 97 (8): 31-36.

Fortin,D. R. and M.S. Renton. 2003. Consumer acceptance of genetically modified foods in New Zealand. *British Food Journal* 105 (1/2): 42-58.

Gianessi, L.P., C.S. Silvers, S. Sankula, and J.E. Carpenter. 2002. Plant biotechnology: current and potential impact for improving pest management in U.S. agriculture: An analysis of 40 case studies, http://www.ncfap.org/40CaseStudies/MainReport.pdf (date accessed: 10 October 2007).

Gomez-Barbero, M., Berbel, J. and Rodriguez-Cerezo, E. 2008. BT-corn in Spain: The performance of the EU’s first GM crop. *Nature Biotechnology* 26 (4): 384-386.

Gough, O. and P.D. Sozou. 2005. Pensions and retirement savings: cluster analysis of consumer behaviour and attitudes. *International Journal of Bank Marketing* 23 (7): 558-570.

Gyau, A., and A. Spiller. 2007. The role of organizational culture in modeling buyer-seller relationships in the fresh fruit and vegetable trade between Ghana and Europe. *African Journal of Business Management* 1(8): 218-229.

Hubbell, B.J., M.C. Marra, and G.A. Carlson. 2000. Estimating the demand for new technology: Bt cotton and insecticide policies. *American Journal of Agricultural Economics* 82 (1): 118-132.

Isserman, A. M. 2001. Genetically modified food: Understanding the social dilemma. *American Behavioural Scientist* 44: 1225-1232.

Kolady, D.E., and W. Lesser. 2006. Who adopts what kind of technologies? The case of Bt eggplant in India. *AgBioforum* 9 (2): 94-103.

Krishna, V.V., and M. Qaim, 2007. Estimating the adoption of Bt eggplant in India: Who benefits from public-private partnership? *Food Policy* 32 (5/6): 523-543.

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Menrad, K., S. Gaisser, and B. Hüsing. 2003. Gentechnik in der Landwirtschaft, Pflanzenzucht und Lebensmittelproduktion, Heidelberg.

Merrill, J., J. Goldberger, and J. Foltz. 2005. The adoption of genetically engineered crop varieties in Madison, Wisconsin (USA).

Miles, S., O. Ueland, and L.J. Flewer. 2005. Public attitudes towards genetically-modified food. *British Food Journal* 107 (4): 246–262.

Nelson, C.H. 2001. Risk perception, behaviour and consumer response to genetically modified organisms. *American Behavioural Scientist* 44: 1371-1388.

O'Connor, E. C. Cowan, G. Williams, J. O'Connell, and M. Boland. 2005. Acceptance by Irish consumers of a hypothetical GM dairy spread that reduces cholesterol. *British Food Journal* 107 (6): 361 – 380.

Onyango, B., R. Govindasamy, W. Hallman, H. Jang, and V. Puduri. 2004. Consumer acceptance of genetically modified foods in Korea: Factor and cluster analysis. Food policy institute working paper WP1104-015.

Payne, J., J. Fernandez-Cornejo, and S. Daberkow. 2003. Factors affecting the likelihood of corn rootworm Bt seed adoption. *AgBioForum* 6 (1/2): 79-86.

Perry, J., M. Morehart, D. Banker, J. Johnson. 1997. Contracting—A business option for many farmers. *Agricultural Outlook,* May, Economic Research Service, USDA, Washington, DC.

Qaim, M. and W. de Javry. 2003. Genetically modified crops, corporate pricing strategies and Farmers' adoption: The case of Argentina. *American Journal of Agricultural Economics* 85 (4): 814-828.

Saba, A. and M. Vassallo.2002. Consumer attitudes towards the use of gene technology in tomato production. *Food Quality and Preference* 13 (1): 12-23.

Sankular, S., G. Mormon, and E. Blumenthal. 2005. Biotechnology derived crops planted in 2004: Impacts on US agriculture. www.ncfap.org/whatwedo/pdf/2004biotechimpacts.pdf (Date accessed: 10 October 2007).

Slovic, P. 1993. Perceived risk, trust and democracy. *Risk analysis* 13 (6): 675-682.

Sugar, C.A. and G.M. James. 2003. Finding the number of clusters in a dataset: An information theoretic approach. *Journal of the American Statistical Association* 98 (463): 750-63.

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Sundig, D. and D. Zilberman. 2001. The agricultural innovation process: Research and technology adoption in changing agricultural sector. In B.L. Gardner and G.C. Rausser (Eds), *Handbook of Agricultural Economics* (1A, 207-261). Amsterdam: North Holland.

Van Scharrel, A 2003. Determinants of South Dakota farmers' adoption of genetically modified corn and soybeans, Ann Arbor; MI.

Voss, J., Spiller, A., Enneking, U. (2009): Zur Akzeptanz von gentechnisch verändertem Saatgut in der deutschen Landwirtschaft, Agrarwirtschaft 58 (3): 155-167.

Weber, W.E., T. Bringezu, I. Broer, J. Eder, and F. Holz. 2007. Co-existence between GM and non-GM maize crops: Tested in 2004 at the field scale level. (Erprobungsanbau 2004). *Journal of Agronomy and Crop Science* 193: 79-92.

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Appendix 1.

Table 3. Mean and standard deviations of statements on the clustering variables.

	Cluster 1 n=117 / 37.6%		Cluster 2 n=42 / 13.5%		Cluster 3 n=65 / 20.9%		Cluster 4 n=59 / 19.0%		Cluster 5 n=28 / 9.0%		F-Stat
	μ	σ	μ	σ	μ	σ	μ	σ	μ	σ	
Acceptance by social environment											
The use of GM seeds is accepted in my family	0.87	0.59	0.12	0.71	-0.06	0.86	1.05	0.66	-1.14	0.85	33.43***
My village community would accept the cultivation of GM seeds	0.41	0.51	-0.15	0.49	-0.45	0.59	0.39	0.70	-0.89	0.79	65.43***
My local environment would accept the use of GM seeds	0.28	0.61	-0.36	0.76	-0.68	0.66	0.80	-0.93	0.72	0.79	44.85***
Pressure from the industry											
The use of GM seeds will become a matter of course with my colleagues	0.27	0.58	0.34	0.57	-0.45	0.59	0.98	0.51	-0.68	0.72	63.23***
Structural change in agriculture will make the use of BT corn indispensable	0.10	0.76	0.29	0.75	-0.45	0.59	0.98	0.51	-0.68	0.72	59.90***
Cost effectiveness											
GM seeds are advantageous from an economic point of view	0.77	0.64	-0.43	0.59	0.44	0.80	1.34	0.51	-0.86	0.80	77.29***
Work effectiveness in agriculture will be improved by the use of GM seeds	0.74	0.62	-0.02	0.84	0.44	0.69	1.39	0.56	-0.44	0.89	45.98***
Manageability of GM seeds											
Crop yields from GM seeds are suited for feedstuffs	0.64	0.74	-0.05	0.76	0.05	0.92	0.76	0.84	-0.78	0.80	22.27***
I am of the opinion that the use of crop yields derived from GM seeds is unproblematic as far as the production of energy is concerned	1.15	0.60	0.59	0.89	0.34	0.91	1.25	0.80	-0.39	0.83	34.58***
I am of the opinion that a co-existence of GM seeds and conventional seeds is possible.	0.95	0.72	0.45	0.83	0.46	0.83	1.19	0.78	-1.07	0.81	47.26***
Semantic differential: useful vs. superfluous.	0.56	1.20	-0.05	1.14	0.18	1.12	0.98	1.36	-1.39	0.88	21.47***

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Appendix 2.

Table 4. Mean and Standard Deviation of Information, Risk and General Attitudes towards GM

	Cluster 1 n=117 / 37.6%		Cluster 2 n=42 / 13.5%		Cluster 3 n=65 / 20.9%		Cluster 4 n=59 / 19.0%		Cluster 5 n=28 / 9.0%		F-Stat
	μ	σ	μ	σ	μ	σ	μ	σ	μ	σ	
Level of informedness											
I am well informed about current developments in the field of GM seeds.	-0.04	0.78	0.02	0.92	-0.23	0.81	0.34	0.88	0.07	0.86	3.82***
I know the arguments of the supporters of GM seeds.	0.60	0.68	0.52	0.74	0.48	0.75	0.93	0.61	0.86	0.52	4.76***
I have already been able to obtain a comprehensive overview of GM seeds.	-0.26	0.86	-0.19	0.97	-0.34	0.97	0.08	0.92	0.04	1.00	2.29
I was already able to get a detailed picture of GM seeds	-0.30	0.83	-0.38	0.94	-0.54	0.81	0.08	0.86	0.94	0.94	4.40**
Willingness to take risk											
With me the decision for the adoption of biotechnology is mainly dependent on the economic benefit.	0.89	0.80	0.93	0.46	0.66	0.78	1.02	0.80	0.32	0.86	5.13***
Personally, I am prepared to take a higher risk for a greater success of my farm.	0.42	0.84	0.12	0.83	0.11	0.91	0.61	0.77	0.11	0.96	4.09**
With critical questions I stick to my principles and in turn even accept a smaller income.	0.06	0.82	0.45	0.83	0.48	0.67	0.07	0.91	0.82	0.77	7.84***
General attitude towards plant genetic engineering											
I share the objections of the opponents of GM seeds.	-0.60	0.63	0.02	0.82	-0.02	0.65	-0.76	0.73	0.93	0.66	40.01***
Genetic engineering has a negative impact on agriculture.	-0.46	0.72	0.05	0.66	0.08	0.87	-0.72	0.83	1.04	0.74	31.23***
Protests against genetic engineering have to be extended.	-1.33	0.37	-0.71	0.74	-0.86	0.92	-1.41	0.70	0.04	1.17	23.95***
The implementation of genetic engineering must be stopped in Germany.	-1.20	0.59	-0.54	0.90	-0.62	1.00	-1.44	0.70	0.79	0.92	47.69***
I don't understand the supporters of genetic engineering in agriculture.	-0.85	0.75	-0.26	0.94	-0.53	0.89	-1.20	0.78	0.29	1.01	19.37***

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