Great Plains Sociologist

Volume 18 | Issue 1 Article 5

2006

Agricultural Producers' Use of Genetically Modified Organisms

Michael E. Lawson

Donna A. Hess

Satoko Hirai

Great Plains Sociologist
Volume 18, 2006/2007

Agricultural Producers' Use of Genetically Modified Organisms

Michael E. Lawson* Donna J. Hess Satoko Hirai

Abstract A random sample of agricultural producers from North and South Dakota, Minnesota, Iowa, and Wisconsin is used to examine producers' decisions to use or not use genetically modified organisms. Using the rational choice theoretical framework to guide analyses, the associations between proportion of genetically modified corn acres grown by agricultural producers and perceived cost, perceived risk, and perceived benefit. Results indicated that 1) perceived cost was significantly, negatively associated with proportion of GM corn acres planted; 2) perceived risk was significantly, negatively associated with proportion of GM corn acres planted; and 3) perceived benefit was significantly, positively associated with proportion GM corn acres planted.

INTRODUCTION

Agricultural producers (farmers and ranchers) have adopted genetically modified organisms (GMO)[1] at arguably the quickest rate of any farming technology in history (Conko 2003). The genetic modification of agricultural plants and animals—often referred to as agricultural biotechnology—has sparked substantial debate (Barham 1996; Barham and Foltz 2002; Darr and Chern 2002; Foltz and Chang 2002; Lawson et al. 2003a; Nelson 2001; Shanahan et al. 2001; Wimberley and Thompson 2002; Zarnstorff 2003). Such debate involves not only the biological and agricultural science issues of gene discovery and gene manipulation, but also economic issues such as concerns about the marketing of GMOs, ethical concerns, such as issues related to moral acceptance, and social dimensions, such as consumer attitudes and concerns about the use of GMOs (Lawson et al. 2003a). Opinions range from those suggesting

* Michael E. Lawson, Ph.D., Suzuka National College of Technology, Department of General Education, Shiroko-cho, Suzuka-city, Mie, 510-0294, Japan. e-mail: lawson@genl.suzuka-ct.ac.jp.

[1] A genetically modified organism may be defined as an organism that has been modified by genetic engineering to contain a gene from an outside source (Nelson 2001).

GMOs should be banned altogether to those strongly supportive of their development (Barham and Foltz 2002; Darr and Chern 2002; Foltz and Chang 2002; Lawson, Stover, and Hess 2003; Shanahan, Scheufele, and Lee 2001; Zarnstorff 2003). Proponents of GMOs point to benefits such as their insect, weed, and disease resistant capabilities, while opponents mention issues such as possible threats to human and environmental health. The former argue that GMOs result in saved time, fewer farming inputs, saved money, and increased crop yields, while decreasing reliance on chemical use (Conko 2003). The latter argue that GMOs may be unsafe for human consumption and that wild biodiversity may be harmed by the elimination of beneficial insects, among other living organisms (Conko 2003).

Thus, factors associated with the use and non-use of GMOs by agricultural producers have been extensively reviewed (ACGA 2001a; ACGA 2001b; Barham 1996; Barham and Foltz 2002; Chen, Barham, and Buttle 2001; Christison 1998; Darr and Chern 2002; Foltz and Chang 2002; Lawson et al. 2003; Lawson, Stover, Hess, and Gorham 2003; Light 2000; NASS 2002; Nelson 2001; Shanahan et al. 2001; Wimberley 2002; Wimberley and Thompson 2002; Yearley 2001; Zarnstorff 2003). Some commonly identified factors that positively influence the adoption of GMOs are lower expenses and higher profits (NASS 2002), decreased labor involvement, improved weed control and a reduction in herbicide use (Chen et al. 2001). However, factors such as having to apply more insecticide than expected, having higher expenses than anticipated, and realizing lower profits than expected, have been noted for their adverse influence on the adoption of GMOs (ACGA 2001a). Additionally, consumer and foreign market concerns (ACGA 2001a), the issue of segregation (ACGA 2001b), and possible adverse effects on human and environmental health (Christison 1998; Light 2000), have also been noted as reasons for the de-adoption of GMOs.

While the rate of GMO use has been extensively reviewed, there has yet to be an attempt to explain why individual agricultural producers choose to use or not use GMOs. At a recent international conference on agricultural biotechnology, Darr and Chern (2002:21) commented: "The study completes the objectives and offers a challenge to future researchers to answer not only how quickly are GMOs being adopted, but why farmers are adopting them." The current study responds to this challenge through the use of a rational choice theoretical framework which views the most basic unit of social life as individual human action (Coleman 1990; Scott 1999).

The current paper thus examines the individual agricultural producer's decision to plant GMOs, testing hypotheses stemming from a rational choice theoretical framework that suggests that individuals make decisions after an assessment of costs, risks, and benefits. In applying this framework, three indices are constructed: 1) cost index; 2) risk index; and 3) benefit index. Then, focusing specifically on the adoption of genetically modified (GM) corn, the following associations are examined: 1) the association between producers' scores on the cost index and the proportion of GM corn grown on their farming operations; 2) the association between producers' scores on the risk index and the proportion of GM corn grown on their farming operations; and 3) the association between producers' scores on the benefit index and the proportion of GM corn grown on their farming operations.

Rational Choice Theoretical Model

According to a rational choice perspective, agricultural producers who choose to use GMOs do so because it helps them maximize their utility in reference to their hierarchy of value preferences. That is, use of GMOs is believed to be a benefit to the agricultural producer because they help in achieving a highly valued preference—for instance, profitability (Saltiel et al. 1994). If an action is perceived to benefit the actor by helping that actor achieve a highly

valued preference, the actor will engage in that act. Thus, perceived benefit should be positively related to GMO use if it is believed that GMO use will help achieve a valued preference. At the same time, agricultural producers also factor in the rational calculation of costs and risks associated with their choices. This is because costs and risks influence the likelihood of achieving the highly valued preference (Hechter 1987; Oberschall 1994). According to a rational choice perspective, then, agricultural producers choose to use GMOs after an assessment of cost, risk and benefit. Perceived cost and risk should be negatively associated with GMO use and perceived benefit should be positively associated with GMO use.

Agricultural Producers' Decisions to Use or Not Use GMOs

According to the literature, some of the key benefits perceived to be associated with GMO use are their ability to cut operating expenses like herbicides and fertilizers (Carpenter and Gianessi 2001; Chen et al. 2001; Darr and Chern 2002; Lawson et al. 2003a; Lawson et al. 2003b), their ability to increase crop yields (Carpenter and Gianessi 2001; Lawson et al. 2003b), and their ability to help solve farm surplus (Lawson et al. 2003b; Lemaux 2001 Thompson 2000). The perception that GMO use entails these benefits should positively influence a producer's decision to use the technology.

Further, the perception that GMOs are costly should be negatively associated with an agricultural producer's decisions to use GMOs. The main perceived costs associated with GMO use are that they increase farm surplus (ACGA 2000; Bessieres 2000; Lemaux 2001; Thompson 2000), they require impractical segregation (ACGA 2000b; Lawson et al. 2003b), and that they pose a serious health hazard to consumers (Chandler 2000; Krebs 2000; NFFC 1999; NFFC 2001). The perception that GMO use entails these costs should negatively influence a producer's decision to use the technology.

Lastly, the perception that GMOs represent a risk should be negatively associated with an agricultural producer's decision to use GMOs. The calculation of the expected benefit that might be gained by choosing to use GMOs is tempered by the perception of how probable the receipt of the benefit will be (Turner 1991). Risk influences this calculation. Some of the main perceived risks associated with GMO use are issues of domestic market risk and their future acceptance by U.S. and foreign consumers (ACGA 2001a; Chandler 2000; Darr and Chern 2002; Goldberg 2002; Lawson et al. 2003b) and concern about risks to human health (Chandler 2000; Krebs 2000; Lawson et al. 2003a; Lawson et al. 2003b; NFFC 2001). The perception that GMO use entails these risks should negatively influence a producer's decision to use GMOs.

METHODOLOGY

Sample, Data Collection, and Research Instrument

As part of the research activities of a consortium[2] investigating the social, economic, and ethical aspects of agricultural biotechnology, in July, 2002, a survey on that topic was mailed to a randomly selected sample of agricultural producers in Iowa, Minnesota, North Dakota, South Dakota, and Wisconsin. The survey was designed to determine respondents' attitudes, values, and practices related to GMOs, as well as their thoughts concerning the practical challenges of GMO use. To assure adequate representation of organic producers, the survey was also sent to a sample of certified organic producers in the same five states. The latter sample was obtained from Northern Plains Sustainable Agricultural systems. The larger sample was obtained from a commercial firm that provides names and addresses for samples. The efforts resulted in a sample size of 937 agricultural producers. The response rate was 31 percent.

[2] The Consortium to Address the Social, Economic, and Ethical Aspects of Agricultural Biotechnology. Funded by: The Initiative for Future Agriculture and Food Systems, Cooperative State Research, Education, and Extension Service, United States Department of Agriculture, Under Agreement No. 00-52100-9617.

Null Form of Research Hypotheses

$H_0$1: There is no association between the perceived cost by agricultural producers of using GMOs and the proportion of GM corn acres planted.

$H_0$2: There is no association between the perceived risk by agricultural producers of using GMOs and the proportion of GM corn acres planted.

$H_0$3: There is no association between the perceived benefit by agricultural producers of using GMOs and the proportion of GM corn acres planted.

Variables and Their Measurement

Dependent Variable. The dependent variable in this study was proportion of GM corn acres planted. This was a ratio comparing the number of GM corn acres a producer had planted relative to the total number of acres the producer had planted in that same crop. Corn is one of America's leading crops (Barkema 2000). The proportion of GM corn acres planted was used as the dependent variable in this study because of the prevalence of GM corn in U.S. agricultural (Conko 2003; Zarnstorff 2003). In 2002, 34 percent of all corn grown in the U.S. was a GM variety (Conko 2003). Additionally, agricultural producers have indicated that among the reasons they use GMOs is because of their resistance to herbicides and pesticides. Some GM varieties have genes inserted that make them resistant to the former and some to the latter. GM corn includes varieties of both types.

Proportion of GM Corn. Respondents were asked, "In 2001, how many total acres did you plant and how many did you plant with GM varieties?" Included in the response category was corn and genetically modified corn. The proportion of GM corn acres planted relative to the total number of corn acres the producer had planted was determined by calculating the ratio.

Independent Variables. The independent variables used in this study were perceived cost, perceived benefit, and perceived risk. An index for each of these variables was created.

Great Plains Sociologist 62
Volume 18, 2006/2007

Perceived Cost Index. The index measuring perceived cost consisted of four survey items (see Table 1) and resulted in a Cronbach's alpha reliability analysis indicated a reliability coefficient of .7151.

Table 1 Perceived Cost Index* (Independent variable for hypothesis 1)

Response Category				
Recoded Items*	***Strongly Disagree***	***Disagree***	***Agree***	***Strongly Agree***
The use of genetically modified organisms will harm American farmers by increasing farm surpluses.	1	2	3	4
The segregation of genetically modified crops from non-genetically modified crops is not practical.	1	2	3	4
If genetically modified crops had to be segregated from non-genetically modified crops at the farm level, I would not plant genetically modified crops.	1	2	3	4
Foods that have been produced using genetic modification pose a serious health hazard to consumers.	1	2	3	4
Range of Possible Scores♦	4			16

•Level of data is ordinal.
*Each item in this index counts equally. Items are not weighted.
♦The range of possible scores for this index is 4-16. The greater the index score, the greater the perceived cost.

Perceived Risk Index. The index measuring perceived risk consisted of five survey items (see Table 2). Cronbach's alpha reliability analysis indicated a reliability coefficient of .7476 for this index.

Table 2 Perceived Risk Index* (Independent variable for hypothesis 2)

Response Category				
Recoded Items*	***Strongly Disagree***	***Disagree***	***Agree***	***Strongly Agree***
I am concerned whether or not U.S. consumers will accept genetically modified crops in the future.	1	2	3	4
I am concerned whether or not foreign consumers will accept genetically modified crops in the future.	1	2	3	4
Farmers have been adequately informed of domestic and export market risk for genetically modified crops.	1	2	3	4
Consumers have been adequately informed about the health risks associated with genetically modified food products.	1	2	3	4
Consumers are adequately protected by the governmental approval process for genetically modified food products.	1	2	3	4
Range of Possible Scores♦	5			20

•Level of data is ordinal.
*Each item in this index counts equally. Items are not weighted.
♦The range of possible scores for this index is 5-20. The greater the index score, the greater the perceived risk.

Great Plains Sociologist 64
Volume 18, 2006/2007

Perceived Benefit Index. The index measuring perceived benefit consisted of three survey items (see Table 3). Cronbach's alpha reliability analysis indicated a reliability coefficient of .6835 for this index.

Table 3 Perceived Benefit Index* (Independent variable for hypothesis 3)

Response Category				
Recoded Items*	***Strongly Disagree***	***Disagree***	***Agree***	***Strongly Agree***
The use of genetically modified organisms will help solve the problem of farm surpluses by finding new uses for crops and livestock.	1	2	3	4
Genetically modified seeds increase crop yields.	1	2	3	4
Genetically modified seeds cut operating expenses like fertilizers and herbicides.	1	2	3	4
Range of Possible Scores♦	3			12

•Level of data is ordinal.
*Each item in this index counts equally. Items are not weighted.
♦The range of possible scores for this index is 3-12. The greater the index score, the greater the perceived benefit.

Data Analysis and Characteristics of the Sample

Data were analyzed using the SPSS computer software program. Descriptive statistics were used to describe the characteristics of the sample and hypotheses were tested using Spearman's rho. Thirty-two percent of the producers' corn crops consisted of GM corn. The median level of education was some college or technical school training but no degree. The average age of the producers was 51.64 years, approximately 95 percent were male and approximately 99 percent identified their race as White.

Results of Hypothesis Testing

The objective of this section is to provide the results of the tests of hypotheses. The decision to accept or reject the null hypothesis is provided. The magnitude and direction of associations are determined using Spearman's rho, and significance is determined with chi-squared.

Hypothesis One: Perceived Cost and GMO Use

The following are the test results for hypothesis one: the greater the perceived cost by agricultural producers of using GMOs, the lower the proportion of GM corn acres planted. The results indicated a significant, moderate, negative association between perceived cost and proportion of GM corn acres planted (rho= -.226, p= .000, see Table 4). Based on these findings, the null hypothesis of no association is rejected. While association is not the same as causation, because of the statistical significance, for our population of agricultural producers, perceived cost might help explain decisions to not use GMOs.

Table 4 Measure of Association with Regard to Hypothesis 1: Proportion of GM Corn Acres Planted by Perceived Cost: 2002

H_R	Statistic	Independent Var.	N	Median	Range	Strength	P Value
H1	Rho	Perceived cost	234	9.00	23-81	-.226***	.000

*p < .05 (one-tail test) **p < .01 (one-tail test) ***p < .001 (one-tail test)

Hypothesis Two: Perceived Risk and GMO Use

The following are the test results for hypothesis two: the greater the perceived risk by

agricultural producers of using GMOs, the lower the proportion of GM corn acres planted.

The results indicated a significant, moderate, negative association between perceived risk and proportion of GM corn acres planted (rho= -.239, p= .000, see Table 5). The null hypothesis of no association is rejected. For the population from which this sample was drawn, perceived risk might help explain decisions to not use GMOs.

Table 5 Measure of Association with Regard to Hypothesis 2: Proportion of GM Corn Acres Planted by Perceived Risk: 2002

H_R	Statistic	Independent Var.	N	Median	Range	Strength	P Value
H2	Rho	Perceived risk	263	13.00	27-86	-.239***	.000

*p < .05 (one-tail test) **p < .01 (one-tail test) ***p < .001 (one-tail test)

Hypothesis Three: Perceived Benefit and GMO Use

The following are the test results for hypothesis three: the greater the perceived benefit by agricultural producers of using GMOs, the greater the proportion of GM corn acres planted.

The results indicated a significant, moderate, positive association between perceived benefit and proportion of GM corn acres planted (rho = .229, p= .000, see Table 6). The null hypothesis of no association is rejected. Because of the statistical significance, for the population from which this sample was drawn, perceived benefit might help explain producers' decisions to use GMOs.

Table 6 Measure of Association with Regard to Hypothesis 3: Proportion of GM Corn Acres Planted by Perceived Benefit: 2002

H_R	Statistic	Independent Var.	N	Median	Range	Strength	P Value
H3	Rho	Perceived benefit	232	8.00	22-89	.229***	.000

*p < .05 (one-tail test) **p < .01 (one-tail test) ***p < .001 (one-tail test)

Table 7 Measure of Association with Regard to Hypotheses: Proportion of GM Corn Acres Planted by Several Independent Variables: (2002)

H_R	Statistic	Independent Var.	N	Strength	P Value	Decision on Null Hypothesis (No Association)
H1	Rho	Perceived cost	234	-.226***	.000	Reject
H2	Rho	Perceived risk	263	-.239***	.000	Reject
H3	Rho	Perceived benefit	232	.229***	.000	Reject

*p < .05 (one-tail test) **p < .01 (one-tail test) ***p < .001 (one-tail test)

SUMMARY

Null hypotheses one through three were rejected (see Table 7). For producers, the perception of cost and risk were significantly, negatively related to the proportion of GM corn acres planted, and perception of benefit was significantly, positively related to proportion of GM corn acres planted (see Table 7). For the population from which the sample was drawn, as

measured by the indices in the current study, there was evidence to support that decisions to use GM corn are associated with the perception of the crop either being costly, risky, and beneficial.

DISCUSSION

Perceived Cost

Some producers view GMO use as costly in the sense that such use is harmful because it increases farm surplus. While previous analyses indicated mixed results, it has been shown that some producers believe that GM crops worsen the perceived (Baldwin 2003) food surplus problem in the U.S. (ACGA 2000; Bessieres 2000; Lemaux 2001; Thompson 2000).

Further, segregation has been shown to complicate the farming practice (Zarnstorff 2003). Segregation could require that producers ensure purity from the planting stage until the crop is sold (Zarnstorff); it could expose producers to lawsuits stemming from cross-pollination (ACGA 2000b); it could necessitate the use of documentation to verify segregation (Zarnstorff 2003); and it could necessitate the use of additional facilities to ensure that segregation takes place (Zarnstorff 2003). Previous analyses indicated that if GM crops had to be segregated from non-GM crops, many producers would plant fewer acres of the former crops (ACGA 2000b; Lawson et al. 2003a), or not plant GM crops at all (Lawson et al. 2003b).

Additionally, previous analyses have indicated that some agricultural producers are very concerned about possible adverse health effects of GM food (NFFC 1999; NFFC 2001). While these findings are based on nonparametric analyses, it is likely that they hold beyond the current study's sample of producers. It is likely that the influence of the costs of GMOs on decisions to use GMOs would also be felt in the larger population. There is no reason to believe that the influence of such costs would affect producers in the population differently than in the sample.

Perceived Risk

Uncertainty and concern about the future acceptance of GM crops by U.S. and foreign consumers has been documented in previous analyses (ACGA 2001a; Darr and Chern 2002; Lawson et al. 2003b). The current findings supported Lawson et al.'s (2003b) finding that a majority of producers are concerned about domestic consumers' future acceptance of GM crops. The current findings also supported the fourteen-state ACGA survey that reported that a key reason for a de-adoption shift of GM corn varieties from 2000 to 2001 by Wisconsin farmers was to keep foreign markets open (ACGA 2001a). Further, there was support for Darr and Chern's (2002) finding that foreign market concerns play a role in a declining adoption rate of Bt-corn by Ohio grain farmers. This result was also a possible indication that agricultural producers agree with Goldberg's (2002) warning that producers must be well-informed about the risks of the domestic and export GMO market. It could be suggested that the results of hypothesis two indicated that producers believed that being uninformed about such risks and benefits was in itself a risk that decreased the proportion of GM corn acres planted.

In terms of the significant, negative relationship between risk and proportion of GM corn acres planted, of particular relevance, given the measurement of risk in the current study, may again be that producers' value beneficence (Goreham et al. 2004). The risk index used in the current study included a measure indicating concern about whether foreign consumers would accept GM crops in the future. Goreham et al. (2004) measured producers' value of beneficence using, among others, an item concerning the promotion of GMOs in developing countries to improve incomes of small farmers and an item that indicated that GMOs should be promoted worldwide to produce more food for hungry people. It is possible that if producers, whose value preferences have been demonstrated by Goreham et al. (2004) to be partially characterized by beneficence as measured by the above items, are concerned that foreign

consumers will not accept GM crops in the future, this may be a risk that promotes the decision to not use GM corn. If producers believe that foreign consumers will not accept GM crops, they might also believe that they should not be promoted in developing counties because the incomes of small farmers may not be improved. Also, hungry people, even in developing countries, will not benefit from GMOs if they do not accept them.

It was not surprising that producers might have viewed health-related issues as a risk. This finding lent support to the NFFC's (1999) report that indicated that one of the main areas of concern that farmers have about GMOs are their health effects. This finding also supported the more recent NFFC (2001) finding that agricultural producers' attitudes toward GMOs are characterized by an extreme concern regarding their impact on human health. Findings of a recent analysis indicated that there was a demand by agricultural producers for an immediate assessment of the health effects of GMOs (NFFC 2001). Findings of recent analyses also indicated that agricultural producers believe that consumers are not adequately informed of the health risks of GMOs (Lawson et al. 2003a; Lawson et al. 2003b). When these findings are coupled with the finding that agricultural producers base their GMO planting decisions on ethical considerations (Lawson et al. 2003b), it was not surprising that health risks would be part of a risk index that was negatively associated with proportion of GM corn acres planted.

These findings are based on nonparametric analyses. However, again, it is likely that they hold beyond the current study's sample of producers. It is likely that the influence of the risks of GMOs on decisions to use GMOs would also be felt in the larger population. There is no reason to believe that the influence of such risks would affect producers in the population differently than in the sample.

Perceived Benefit

While some agricultural producers believe that GMOs exacerbate the proposed food

surplus problem in the U.S. (Baldwin 2003) and therefore are costly, others believe that surplus crops can be profitable because they can be exported to third world countries to combat world hunger (Lemaux 2001; Thompson 2000). Many agricultural producers believe that GM crops will enable surplus to be exported to third world countries when before it could not. This is because surplus GM crops can consist of modifications that result in food that contains vitamins or nutrients that are severely lacking in the diets of the poor, and livestock that can be modified to, for instance, produce more milk (Thompson 2000). Also, some agricultural producers believe that GMOs will help solve the problem of farm surpluses by finding new uses for crops and livestock (Lawson et al. 2003b).

This finding supported previous analyses that indicated that greater crop yields are a factor that increases the adoption of GMOs. According to agricultural producers, a major impact of GM crops is their ability to increase yields (Carpenter and Gianessi 2001; Lawson et al. 2003b), and analyses have supported this belief (Carpenter and Gianessi 2001; Conko 2003). A benefit of increased crop yields perceived by some producers is profitability (Lawson et al. 2003a). GM crops, such as Bt-corn, provide protection from insects that were before difficult to control, which resulted in billions of dollars lost to lower crop yields (Conko 2003). Results of the current study indicated support for previous analyses that have found that agricultural producers perceive increased crop yields as a benefit of GM crop use.

Additionally, the current study's finding that perceived benefit was positively associated with GM corn acres planted, was not surprising when considering that the index included a of measure of decreased operating costs. This finding lent support to Darr and Chern's (2002) finding that decreased operating costs were the main benefit of GMO adoption. Also supported is the finding indicated in the NASS (2002) survey that agricultural producers based decisions to plant more acres of GM corn in 2002 than in 2001 because of lower operating expenses.

Further, there was support for Chen et al. (2001) finding that a reduction (cut in operating costs) in overall herbicide need was a main reason that agricultural producers planned to increase future adoption of herbicide resistant GM crops. Support was also given to Lawson et al. (2003a), who found that agricultural producers believed they were better off financially planting GM seed because such seed cuts herbicide costs. Additionally, support was found for Fitzgerald (2003) and Lawson et al. (2003a), who found that a primary benefit of GM seeds according to agricultural producers is the belief that they help cut operating costs by reducing the need for fertilizer.

While these findings are based on nonparametric analyses, it is likely that they hold beyond the current study's sample of producers. It is likely that the influence of the benefits of GMOs on decisions to use GMOs would also be felt in the larger population. There is no reason to believe that the influence of such benefits would affect producers in the population differently than in the sample.

WEAKNESSES

This study contained several weaknesses. Results were based on a sample that was quite homogenous in terms of demographic characteristics. Additionally, the indices of the current study would have likely been improved if a measure of the impact that GMOs have on the environment had been included. Due to data limitations, the current study omitted the consideration by producers of what is probably considered a vital aspect of GMOs. By not including a measure of the impact that GMOs have on the environment, this was not considered in producers' assessments of cost, risk and benefit. Lastly, hypotheses one through three were tested without controls for possible confounding variables. Thus, while associations were examined, it is unknown what the independent effects of the independent variables on the dependent variable were.

IMPLICATIONS OF RESEARCH FINDINGS

This study attempted to add to the literature that addresses GMO use. The adoption-diffusion model had guided previous research on GMO use, which explained factors related to the rate of GMO adoption. The current study tried to answer the call for an investigation of not only how quickly GMOs are being adopted, but also why they are being adopted. The rational choice theoretical framework provided an alternative approach to guide the investigation. Some evidence was found to support the idea that agricultural producers might assess cost, risk, and benefit when they decide to use or not use GMOs.

REFERENCES

American Corn Growers Association. 2000. "Arrogance of U.S. Exporters and some Domestic Farm Organizations Ruins U.S. Farmers." Retrieved May 10, 2004 (http://www.acga.org/news).

American Corn Growers Association (a). 2001. "Grower Survey Shows Farmers Report Planting Six Percent Fewer Acres of GMO Corn Varieties in 2001 Compared to 2000." Retrieved February 13, 2002 (http://www.organicconsumers.org/gefood/lesscorn717.cfm).

American Corn Growers Association (b). 2001. "Results Show Considerable Concerns over Segregation and Liability and Support for Foreign Customer Choice." Retrieved February 13, 2001 (http://www.acga.org/news/2000/062200.htm).

Baldwin, Nick. 2003. "America: The Land of Plenty." Retrieved on May 12, 2004 (http://www.agron.iastte.edu/).

Barham, Bradford L. 1996. "Adoption of a politicized technology: rBST and Wisconsin dairy farmers." *American Journal of Agricultural Economics* 78:1056-1069.

Barham, Bradford L. and Jeremy Foltz. 2002. "rBST adoption in the United States: that was the juggernaut...that wasn't." *Choices: The Magazine of Food, Farm and Resource Issues* 17:15-22.

Barkema, Alan D. 2000. "U.S. Agriculture's Trade Prospects." *The Main Street Economist.* Retrieved May 27, 2004 (http://www.mainstreeteconomist.com/).

Carpenter, Janet and Leonard Gianessi. 2001. "Herbicide Tolerant Soybeans: Why Growers are Adopting Roundup Ready Varieties." *Agbioforum* 2(2). Archived at: (www.agbioforum.org).

Chandler, David L. 2000. “Down on the Farm.” *Boston Globe*. Retrieved on June 12, 2004 (http://www.mindfully.org/GE/Down-On-Farm-Biotech.htm).

Chen, Lucy, Bradford L. Barham, and Frederick H. Buttle. 2001. "Update on the Adoption and De-Adoption of GMO Varieties in Wisconsin." *Wisconsin Farm Research Summary* 6.

Christison, Bill. 1998. “Family Farmers Warn of Dangers of Genetically Engineered Crops.” *In Motion Magazine.* Retrieved February 13, 2002 (http://www.inmotionmagazine.com/genet1.html).

Coleman, James S. 1990. *Foundations of Social Theory*. Cambridge: Belknap Press.

Conko, Gregory. 2003. "The Benefits of Biotech." Pp. 1-13 in *The Boons of Biotech.* Edited by Bishop Grewell and Clay Landry. Lafayette. Purdue University Press.

Darr, David A. and Wen S. Chern. 2002. "Analysis of Genetically Modified Organism Adoption by Ohio Grain Farmers." Pp. 1-32 in *Agricultural Biotechnology: New Avenues for Production, Consumption and Technology Transfer*. Italy.

Fitzgerald, Sara J. 2003. "Putting the EU in Its Place: Why Filing a GMO Case with the WTO is Crucial." *Policy Research and Analysis*. Retrieved June 3, 2004 (http://www.heritage.org/research/europe/em855.cfm).

Foltz, Jeremy D. and Hsiu-Hui Chang. 2002. "The adoption and profitability of rBST on Connecticut dairy farms." *American Journal of Agricultural Economics* 84:1021-1043.

Goldberg, Gary. 2002. "Good for the Farmer?" *American Corn Growers Association*. Retrieved on May 2, 2004 (http://www.mindfully.org/GE/American-Corn-Growers-Assoc.html).

Goreham, Gary A., Youngs, George, A., Jr., Hess, Donna J., and Steven Sapp. "Ethical Principles Used by Farmers Regarding Their Use of Genetically Modified Organism." Paper presented at the annual meeting of the Rural Sociological Society, Sacramento, CA. August 2004.

Hechter, Michael. 1987. *Principles of Group Solidarity*. Berkeley: University of California Press.

Krebs, A.V. 2000. "Farmers, National Family Farm Coalition Launch Monsanto Price-Fixing, Anti-Trust Suit." *The Agribusiness Examiner* 60:1-7.

Lawson, Michael E., Stover, Ronald G., and Donna J. Hess. 2003a. "A Sociological Investigation of Attitudes and Practices Regarding Agricultural Biotechnology." *The Great Plains Sociologist* Vol. 15, No. 1:1-13.

Lawson, Michael E., Stover, Ronald G., Hess, Donna J. and Gary A. Goreham. 2003b. "Agricultural Biotechnology and the Midwestern Agricultural Producer." Published on South Dakota State University's Rural Life Census Data Center Web Page. (http://sdrurallife.sdstate.edu/). (Link to: "Biotech Producers' Survey").

Lemaux, Peggy G. 2001. "Nudging Mother Nature: The Promise and Reality of Ag. Biotech for Farmers." Retrieved on May 11, 2004 (http://ucbiotech.org/resources/biotech/talks/pipeline/4/sandieg.html).

Light, Julie. 2000. "Seeds of Resistance: Grassroots Activism vs. Biotech Agriculture." *CropWatch*. Retrieved February 14, 2002 (http://www.corpwatch.org/issues/PID.jsp?articleid=572).

National Agricultural Statistics Service. 2002. *USDA Statistical Bulletins*. Retrieved February 15, 2002 (http://usda.mannlib.cornell.edu/reports/general/sb/).

National Family Farm Coalition. 1999. "Statement of Bill Christison, President--National Family Farm Coalition." Retrieved June 11, 2004 (http://www.psrast.org/usfarmlawst.html).

National Family Farm Coalition. 2001. “Farmers' Declaration on Genetic Engineering in Agriculture.” Retrieved February 13, 2002 (http://www.nffc.net/bio1.htm).

Nelson, Carl H. 2001. "Risk Perception, Behavior, and Consumer Response to Genetically Modified Organisms." *American Behavioral Scientist* 44(8):1371-1388.

Oberschall, Anthony R. 1994. "Rational Choice in Collective Protests." *Rationality and Society* 6(1): 79-100.

Saltiel, John, James W. Bauder, and Sandy Palakovich. 1994. "Adoption of Sustainable Agricultural Practices: Diffusion, Farm Structure, and Profitability." *Rural Sociology* 59:333-349.

Shanahan, James, Scheufele, Dietram, and Eunjung Lee. 2001. "Attitudes about Agricultural Biotechnology and Genetically Modified Organisms." *Public Opinion Quarterly* 65:267-281.

Thompson, Larry. 2000. "Are Bioengineered Foods Safe?" *U.S. Food and Drug Consumer Magazine*. January-February: 22-28.

Turner, Jonathan, H. 1991. *The Structure of Sociological Theory*. 5th Edition. Belmont: Wadsworth Publishing Company.

Wimberley, Ronald C. 2002. “Social, Agricultural, and Environmental Interdependence.” Pp. 1-13 in *The Social Risks of Agriculture: Americans Speak Out on Food, Farming, and the Environment*. Edited by Ronald C. Wimberley et al. Westport: Praeger Publishers.

Wimberley, Ronald C. and Alton Thompson. 2002. "Agriculture's Social Risks and Directions." Pp. 117-124 in *The Social Risks of Agriculture: Americans Speak Out on Food, Farming, and the Environment*. Edited by Ronald C. Wimberley et al. Westport: Praeger Publishers.

Yearley, Steven. 2001. "Mapping and Interpreting Societal Responses to Genetically Modified Crops and Food." *Social Studies of Science* 31(1):151-160.

Zarnstorff, Mark. 2004. "Biotechnology—What does the Future Hold?" Retrieved on June 18, 2003 (http://www.ag-risk.org/NCISPUBS/LAIPPUB/Art0600.htm).