Explaining attitudes toward genetically modified foods in the European Union

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Abstract

This article examines the factors that condition citizens' attitudes toward genetically modified (GM) foods by considering individual-level attitudes in 15 European Union member states. Previous research has shown that European attitudes toward GM foods are influenced by overall levels of scientific literacy, consumer exposure to media coverage, and broader socio-political preferences. This article seeks to expand on this literature by testing some of these explanations in a multivariate analysis. To test our propositions, we develop and estimate a logistic regression model using data derived from Eurobarometer surveys. While the sources of information that people value and their attitudes toward EU policy in related areas explain to some extent support for GM foods, our strongest finding confirms the importance of public understanding of science as a basis for support for this emerging technology.

Keywords

European Union, GM food, public opinion, regulation

> Genetically modified organisms (GMOs) are here to stay. Yet the public in many countries distrusts GMOs, often seeing them as part of globalization and privatization, as being 'anti-democratic' or 'meddling with evolution.' In turn, governments often lack coherent policies on GMOs, and have not yet developed and implemented adequate regulatory instruments and infrastructures. (Louise O. Fresco, Assistant Director-General, FAO Agriculture Department)[1]

Introduction

Though the biotechnology industry remains relatively nascent, observers have suggested that we are in the midst of the 'Biological Century' (Evenson, 2002; Henderson et al., 1999).[2] Genetically modified (GM) foods represent a central element in the modern biotechnology revolution, with the market for agricultural biotechnology doubling from US$3 billion in 2001 to over US$6 billion in

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2006 (*Economist*, 2008). Over 134 million hectares (330 million acres) were cultivated worldwide with GM crops in 2009, and this figure is projected to surpass 200 million hectares by 2015 (*Chemical Week*, 2007; James, 2009). Despite such rapid growth, the consumption of GM food products has remained outside of the attention of some segments of the population, while stirring significant controversy among others. For instance, surveys by the Pew Initiative on Food and Biotechnology (2003) found that Americans know surprisingly little about GM foods and the regulation of such products. According to Pew results, only 34 percent of Americans had heard 'a great deal' or 'some' about GM foods. Further, only 24 percent of respondents acknowledged that they believed they'd eaten GM foods. Such attitudes come at a time when it is estimated that 60–70 percent of the packaged foods sold in American supermarkets are likely to contain GM ingredients (Aziakou, 1998). Given this fundamental disconnect between public opinion and popular behavior, debates over the use of GM foods and crops represent a critical nexus between public policy and public opinion.

The framing of agricultural biotechnology issues likely influences the attitudes of the polity at large. For instance, biotechnology policy and the use of GM foods are often conceptualized as trade issues. Following the European Union's moratorium on the sale of GM foods in 1998, the United States challenged the European position and took its case to the World Trade Organization. In framing GM foods as a trade issue, factors such as national economic competitiveness, market share, export revenue, and potential risks to farmers who cultivate GM crops matter a great deal. Currently, American biotechnology multinationals such as Monsanto and Dupont, and Switzerland's Syngenta AG, dominate the global market for GM seeds. Moreover, approximately 50 percent of GM crops worldwide are grown in the US, while no European country ranks in the top ten (James, 2009). In 2009, although 14 million farmers in 25 countries planted GM crops, very little of this cultivation took place in Europe (James, 2009). The top six producers of biotech crops by area – the US, Brazil, Argentina, India, Canada, and China – account for over 95 percent of the total. Spain, which ranks twelfth overall, is the highest ranking European country by area. At the other end of the spectrum, GM crops 'cover only about 0.12 per cent of Europe's agricultural land and the continent accounts for just 0.08 per cent of the area growing them worldwide' (Lean, 2010: 22). Thus, from a neoliberal trade perspective, GM foods generate a wider variety of products, which ultimately increase competition among producers, enhance consumer choice, and contribute to the competitive marketplace for food products.

In contrast to framing the GM foods issue as a trade and competitive matter, others define GM foods primarily in terms of consumer choice. Consumers seek to access a wider variety of agricultural products (such as those created by genetic modification) in the belief that increased agricultural varieties will lead to lower food costs. Experimental studies have also demonstrated that consumers – including those in Europe – are more likely to select GM foods over organic foods in the event that such foods offer a 'price advantage coupled with a consumer benefit' (Knight et al., 2007: 508). In the broader context of consumer choice, the GM food debate also has considerable economic development implications. While developed countries have sought to devise effective and ethical foreign assistance programs, debates over whether and which types of GM foods to export to the developing world have been highly contentious. For instance, though nearly three million people risked starvation at the time, the Zambian government rejected thousands of tons of US corn in 2002, citing the lack of 'scientific consensus on GM' (Bohannon, 2002: 1153).

The reference to scientific consensus suggests GM foods are also framed as a public health issue. From this perspective, the long-term health effects of GM food products remain uncertain. Given the relatively recent emergence of the biotechnology revolution, there is simply a lack of long-term scientific studies establishing the safety of such products. Moreover, critics of agricultural biotechnology, such as Jeremy Rifkin (1998), have argued that it is imprudent to expose consumers to such products in the absence of long-term safety evidence. In this context, government regulators around the world are forced to make a fundamental risk–benefit calculation that is acceptable to their respective polities, yet they must do so in the absence of complete information. Consequently, governments in this context are faced with a decision-making dilemma often found when regulating new medicines (Ceccoli, 2004). That is, governments typically seek to avoid Type I errors in which products later found to be unsafe or ineffective are approved for mass consumption. Such regulatory errors can adversely affect large numbers of citizens and undermine public confidence in regulatory institutions.

On the other hand, the same public health rationale could be used to make a case in support of GM foods. Proponents argue that GM foods show tremendous promise for eradicating world hunger, reducing food insecurity and improving the conditions of millions of citizens worldwide, especially those in the developing world. According to the Food and Agriculture Organization of the United Nations, the world's population grows by two people every second and will reach eight billion people in 2030. In addition, caloric demand continues to grow as a consequence of changes in eating habits (mainly in countries like China and India). Acknowledging that nearly one-fifth of the population in the developing world remains undernourished, GM proponents point out that one-third of the earth's population depends on rice, yet rice contains little nutritional content (Specter, 2002). Advances in 'nutraceutical' products such as Golden Rice promise to add beta-carotene and other nutrients to rice that will aid in stemming the occurrence of vitamin A deficiency and the loss of eyesight. Another nutraceutical product, Bt corn, has been used to thwart the pernicious effects of certain fungi, known to overtake a number of organic corn varieties. Unlike the Type I errors described above, regulators must also caution against Type II errors as errors of omission by denying the approval of products that ultimately prove to be not only safe but also socially beneficial. Therefore, on the basis of both protecting and promoting public health, regulatory agencies must maintain a fine balance between keeping harmful products away from consumers and ensuring that promising new food products reach consumers.

Regulating GM foods in the European Union

The consumption of GM foods has been an especially contentious issue across European polities.[3] The European Union defines genetically modified organisms (GMOs) 'as organisms in which the genetic material (DNA) has been altered in a way that does not occur naturally by mating or natural recombination' (European Union, 2004). Given the variety of ways in which the issue of GM foods can be framed – from trade and economic competitiveness to consumer choice to protecting and promoting public health – European governments and polities have been much slower than their American counterparts to embrace the revolution of GM foods. Perhaps it is not surprising that *The Economist* recently noted: 'In Europe, opposition to GM food appears as strong as ever, despite increasingly strident scientific dissent.'[4] Like the United States, member states of the European Union represent a wide demographic, economic, and political canvas. Yet, the European Union imposed a ban on genetically modified crops in 1998 and altered its regulatory framework for GM foods, which became effective in 2002.[5] Though the ban was lifted in 2003, the EU continued its measured regulatory response by imposing strict labeling standards and tough rules that ensure products with genetically modified contents can be traced by the authorities. One particularly controversial episode involved the European Commission's 2005 approval of Monsanto's genetically modified maize, MON863, for use as animal feed despite the opposition of more than half of the EU's member state governments. The product was approved for human consumption in 2006.

These decisions raised a number of important safety concerns from EU member states, prompting the *Daily Mail* of London to run the headline 'Coming to our plates, the GM corn that harmed rats' (Poulter, 2005).

Though the EU operates on the premise of consensus, attitudes and policies toward GM foods at the national level reflect significant divisions. Spain has been the only European Union member state thus far to plant significant amounts of GM crops. On the other hand, public opinion in Britain has strongly opposed the planting of GM crops. This issue gained significant momentum in early 2004 when, after a three-year testing period and despite significant opposition in opinion polls, the British government approved the commercial cultivation of Monsanto's MON863. The debate and subsequent policy announcement from London highlighted the significant discord between public opinion and policy. Perhaps ironically, later in the same week that the then British prime minister Tony Blair announced the changes in Britain, a potentially disturbing announcement was made about GM crops on the other side of the Atlantic. The North American Commission for Environmental Cooperation (CEC) released a report indicating that American GM corn exported to Mexico could threaten native varieties of Mexican corn (CEC, 2004).

Despite the Blair government's decision, the 'precautionary principle' regarding risk management has been embraced throughout Europe. It suggests that if there is legitimate concern over the safety of a new product, that product should not be approved for marketing to the mass public. This 'look before you leap' approach to regulation, which has been applied in a variety of European-wide environmental, health and safety regulations, implies that governments are not inclined to rely solely on traditional cost–benefit analyses when informing regulatory decision-making.[6] A number of food safety mishaps over the past decade have repeatedly undermined public confidence in the safety of food. Such confidence continues to remain tenuous at best, particularly across the European continent. Debates over GM foods, combined with highly salient food safety scares, such as dioxin contamination, BSE ('mad cow disease'), the use of growth hormones in beef, and concerns over amounts of melamine in baby formula, have heightened the concerns of both North American and European consumers about the significance of food security (Nestle, 2002, 2003). Indeed, food safety scares, though not necessarily common, are often widespread in nature. Consequently, public confidence in food security systems remains a critical consideration.

Outline of this study

In order to better understand the rationale behind such sentiment, this study develops and tests several hypotheses regarding individual support for the use of GM foods. The article begins by exploring patterns of support for GM food products across the 15 member states of the European Union prior to the historic 2004 enlargement. Therefore, individual respondents in this analysis are from Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, the Netherlands, Portugal, Spain, Sweden, and the United Kingdom. We then build on the work of Gaskell and colleagues who propose three potential explanations for the variation in cross-national attitudes toward the use of biotechnology products (Gaskell et al., 1999, 2001, 2003). They argue that scientific literacy, media coverage, and trust in the regulatory process should go a long way to explaining such variation. In their work, Gaskell and colleagues find support for their hypotheses using a variety of univariate tests. We seek to build on this work by incorporating and then testing similar hypotheses in a multivariate model. Specifically, we develop explanations of individual-level support for genetically modified food products based on scientific literacy, consumer exposure to media coverage, and broader socio-political preferences for the direction of EU regulatory institutions. Hypotheses derived from these arguments are then tested in a logistic regression analysis. A logistic regression model will be estimated to determine whether the hypotheses explain the variation in individual support on the part of respondents pooled across the 15 EU member states. Individual-level data are derived from Eurobarometer surveys in the 15 EU member states.

Patterns of support for GM foods in the European Union

The dependent variable in this article is respondent feelings toward the use of genetically modified foods. This dependent variable is operationalized in a manner consistent with a question provided in the Eurobarometer 55.2 survey (Christensen, 2002). Specifically, respondents were asked to agree or disagree with the following question: *Could you please tell me if you tend to agree or disagree with the following statement about genetically modified foods – 'I do not want this type of food*.' Examining the distribution of responses to the question across 15 EU member states illustrates considerable opposition to GM foods. Overall, 72.7 percent of respondents agreed with the statement that they do not want this type of food. Conversely, 19.6 percent disagreed with the statement. Interestingly, responses from survey participants also indicated a great deal of uncertainty over the use of GM foods. Overall, 7.7 percent of respondents reported an answer of 'don't know' when asked the question.

These empirical discrepancies present an interesting puzzle. What individual-level factors serve to divide Europeans over the use of GM foods? Specifically, what factors make European consumers so decidedly opposed to the use of GM foods? The next section develops several potential explanations for these sentiments.

Perspectives on explaining support for genetically modified foods

Individual country studies about public attitudes toward the use of such technologies are not uncommon, particularly those focusing principally on the United States (Pew Initiative, 2003). Moreover, much of the cross-national scholarly work on food safety in general, and GM foods in particular, has focused on transatlantic similarities and differences (Pollack and Shaffer, 2001, 2009). On the other hand, outside of the literature in the field of product marketing, there have been relatively few country-specific cross-national analyses of attitudes toward GM products. A major exception has been the work by George Gaskell and colleagues (Gaskell et al., 1999, 2001, 2003).[7] This article seeks to extend the empirical work of Gaskell and colleagues and expand upon the theoretical development of such cross-national research by developing and testing several explanations for individual-level variations in attitudes toward the use of genetically modified foods. Continuing the approach of Gaskell, this study develops three general types of theoretical approaches for explaining individual-level variation in support for GM foods: scientific literacy, exposure to media coverage, and broader socio-political preferences on the direction of EU regulatory policies. In addition to these theoretical explanations, we control for a variety of standard demographic factors. In the sections to follow, we outline the general logic of these explanations and then generate testable hypotheses from them.

Scientific literacy (or the public understanding of science)

We argue that the degree of public understanding of science can offer an important explanation for the variation in public support for genetically modified foods. The term 'scientific literacy' is often used synonymously with the phrase 'public understanding of science.' Scientific literacy has been defined in many ways (Arons, 1983; Thomas and Durant, 1987) and typically involves ascertaining one's level of scientific knowledge, at both the individual level and societal levels. Perhaps most directly, scientific literacy entails the concrete concept of how much a citizen actually knows about science. A number of studies have attempted to assess scientific literacy in Europe, the United States, and Canada (Durant et al., 1989; Einsiedel, 1994; Miller, 1993, 1998). Attempts to measure scientific literacy at the national level have received considerable scholarly attention, particularly since it is believed to be closely linked to industrial competitiveness (Walberg, 1993).

In addition, social scientists have long been interested in the relationship between scientific literacy, public policy, and democracy (Prewitt, 1982, 1983; Wildavsky, 1995). This connection was well articulated by the United Nations Educational, Scientific, and Cultural Organization (UNESCO), which described scientific literacy as a 'universal requirement if people are not going to be alienated in some degree from the society in which they live' (UNESCO, 2000).[8] In general, a number of economic, political, and cultural arguments can be made in support of scientific literacy as an important public good (McEneaney, 2003). Moreover, Shamos (1995) and others have argued that societies failing to achieve scientific literacy are likely to experience great difficulties in communicating information to the general public, a difficulty which naturally poses significant challenges in terms of governance and the acceptance of new ideas.

It is generally argued that a well-informed and scientifically literate polity can raise the overall level of public discourse and be a precursor to sound science and technology policy and regulation. In this sense, one can differentiate various types of 'publics' and the level of scientific information that is appropriate to those groups. Shamos (1995), for example, differentiates between special interest groups, legislators, and the general public (who may be informed and uninformed, and/or interested and uninterested in science). Thus, the term 'public understanding of science' extends beyond mere scientific literacy and is a useful concept because it encompasses individual *attitudes* toward science. As Prewitt points out: 'Public understanding of science … is necessary … to have reasonable science policies. Public *mis*understanding of science will work its way through the political process and emerge in such detrimental policies … political rather than scientific criteria for setting research policies … and misguided regulations' (1983: 50–1).

According to Prewitt, the relationship between the general citizenry and the scientific community works both ways. On the one hand, when citizens have an adequate level of 'public understanding' regarding science, the polity is more likely to generate 'reasonable science policies' (1983: 50). This is made possible, according to Prewitt, largely because a scientifically 'savvy' citizenry are those 'not bewildered or intimidated by the introduction of new technologies or the arrival of new scientific languages' (1983: 54). In a sense, a scientifically savvy polity better understands science policy as a whole and is therefore more likely to support scientific research and training. On the other hand, the development of a scientifically savvy citizenry does not happen automatically. Indeed, according to Prewitt (1982) and others, the scientific community needs to play an active role in informing the public about scientific developments. In this two-way relationship, it is clear that the public understanding of science will play an ever-increasing role in this era accompanying the biotechnology revolution.

Since the level of knowledge and the perceptions toward science and technology are instrumental in defining one's understanding of science, social scientists need to focus on public *attitudes* toward science. Einsiedel posits that 'cognitions about scientific concepts may trigger more generalized schemas relating to science, the scientific enterprise, roles associated with scientists, which may evoke some evaluative response' (1994: 36). Testing data on Canadian citizens, she contends that 'those who exhibited lower levels of science knowledge or understanding were more likely to be distrustful of science and scientists and were less likely to feel a sense of efficacy about the scientific enterprise' (1994: 41). The opposite finding also applies in that those with higher levels of science knowledge were more likely to be trustful of science on the whole.

Based on the empirical findings of Einsiedel and the arguments of Prewitt regarding the importance of a scientifically savvy citizenry, we argue that in democratic societies the level of scientific literacy should be positively related to support for GM foods. That is, those who have a better understanding of the issues and can more easily grasp their complexity are more likely to see the virtues associated with biotechnology. Conversely, those with lower degrees of scientific literacy are less likely to be supportive of the use of GM foods.

We used three measures to operationalize and later test scientific literacy as an explanatory category. First, we used the answer given by the survey respondent in response to a simple science question which ascertains whether they know the scientifically correct way to test the effectiveness of a new drug. Using the answers to this question, we create an explanatory variable designated *Scientific literacy*. Based on the logic described in the previous paragraph, we hypothesize that respondents who answer this question correctly are more likely to support the use of GM foods. Our second measure used to operationalize scientific literacy relies on respondent self-assessments regarding whether they are well informed about science and technology in general and GM foods in particular. In the former case, respondents were simply asked how well informed they felt about science and technology. In using the variable, *Informed*, we argue that those who feel well informed about science and technology are more likely to support the use of GM foods. Conversely, those identifying themselves as not well informed should, generally speaking, be less supportive because their relative lack of information triggers a more cautious outlook. Finally, we rely on an additional self-assessment question that asks respondents if they think they understand the issue of GM food. In using the variable, *Understand*, we argue that those who feel they understand GM foods are more likely to support GM foods than those who do not. We posit that a relative lack of understanding (at least based on self-assessments) is more likely to create a sense of ambivalence toward GM foods. Such ambivalence (or even outright skepticism) should recede as the individual believes they better understand the issue. Therefore, in operationalizing scientific literacy, we rely on a composite of these three indicators to gauge support for GM foods.

Consumer exposure to media coverage

In addition to scientific literacy, it is important to consider where consumers receive their information when examining the extent to which citizen perceptions affect the use of GM foods. The media have traditionally played important roles in educating the citizenry and acting as a key gatekeeper of information. In these capacities, the media also play a substantial role in opinion formation. However, some have argued that at least part of the controversy over GM foods in Europe is due to the fact that industry, researchers, and public authorities have not done a proper job of educating citizens with regard to the benefits and risks of biotechnology products (Lassen et al., 2001). If this is indeed the case, then political scientists can add to the debate on GM foods by considering the multiple roles of the mass media in society and the manner in which consumers are exposed to such information.

West (2001: 6) argues that the mass media have been challenged by the expansion of several alternative media outlets and coverage has become 'less professional, more heterogeneous, and more tabloid oriented.' Consequently, it is important to understand both how citizens receive political information as well as how they process political information from a variety of media sources. Despite the increasing media fragmentation, some studies have found that the level of political knowledge has remained fairly stable over time (Delli Carpini and Keeter, 1996; Page and Shapiro, 1992; Zaller, 1992). Generally speaking, considerable amounts of political information known to citizens extend beyond mere personal experience (Graber, 1988) and such information is often supplied by the mass media. In addition, if new political information (i.e., information that lies beyond the realm of personal experience) is critical to shaping opinion, it is also important to consider how such information is framed or 'spun' by the media (Iyengar, 1991). Indeed, as Cook and colleagues (2006: 9) demonstrate, media coverage and the related discourse associated with agricultural biotechnology may largely reflect the 'different views, styles, and readership' of newspapers. Such messages inherently contribute to the shaping of public perceptions.

Media coverage often gains intensity in both its depth and its breadth as a response to a singular event or occurrence, and such events become the basis for mobilizing public opinion. Shanahan and colleagues demonstrate how the rapid increase in coverage of agricultural biotechnology issues in the United States between 1990 and 2000 spilled over into Europe (Shanahan et al., 2001). They establish that media coverage of these types of issues has escalated since 1998 because of stories associated with the genetic modification of the dairy system in the United States. Dating as far back as 1993, the US Food and Drug Administration (FDA) approved the use of Monsanto's Posilac as the nation's first official bovine growth hormone.[9] Yet, in 1998 the Canadian government issued a report questioning the safety of the hormone. Following an earlier temporary ban, the European Council permanently banned the bovine growth hormone in 1999 (European Council, 1990, 1999). According to Shanahan and colleagues, 'the BST controversy paved the way for the European experience to catalyze a wider journalistic and, possibly, public opinion reaction' (Shanahan et al., 2001: 268). Similarly, Augoustinos and colleagues (2010: 98) demonstrate in a content analysis of British newspapers that the print media served as a 'battleground of competing interests' during the British GM debate in 2003 and 2004.

Gaskell and colleagues (1999) hypothesize that the quantity of media coverage should influence public attitudes toward biotechnology. Specifically, they argue that greater levels of media coverage are associated with greater public concern regarding the use of biotechnology products. The logic behind this contention is consistent with 'the Mazur hypothesis,' which suggests that increased quantities of media attention and coverage of technological issues tend to elicit a 'negative' or 'conservative public bias' (Mazur, 1981: 106).[10] The experience over the FDA approval of the bovine growth hormone tends to support this logic. However, Gutteling's (2005) study of media coverage of biotechnology issues does not find empirical evidence to support the Mazur hypothesis. Interestingly, and contrary to the Mazur hypothesis, Gutteling (2005: 32–4) finds that non-readers of newspapers have the lowest levels of 'encouragement for biotechnology' and are more concerned about risk, respectively, when compared with readers of the elite and popular presses.

In this case, we are interested in testing a factor much broader than the quantity or tone of media coverage by measuring and testing consumer *exposure* to media coverage. In particular, where consumers get their information should matter a great deal. We use two types of indicators to measure the extent of consumer exposure to media coverage. First, we rely on a series of Eurobarometer questions that ask respondents to rank the importance of television, newspapers and magazines, and the Internet as a source of their information about scientific developments. Specifically, respondents are asked to rank six sources of information based on their importance. Traditionally, newspapers provide more content and analysis than television reports. In addition, the Internet is becoming an increasingly valuable and important source of information about salient public policy issues (Klotz, 2004). Given this tradition of providing less substantive content, we argue that those who rely on receiving news primarily from television should be less likely to support GM foods. Applying the same logic, we argue that those who rely on newspapers and the Internet should be more likely to support GM foods. Based on the logic described above, we created the three explanatory measures of *TV rank*, *News/mag rank*, and *Internet rank*. In addition to the importance of the particular news medium, we operationalize the nature of consumer exposure to media coverage by measuring the frequency with which respondents read articles about science and technology. Thus, we constructed *Reading frequency* as an explanatory variable to capture the effects of consumer exposure to media coverage. In following the logic associated with Gutteling's (2005) empirical results, we hypothesize that those who frequently read about science and technology should be more supportive of GM foods, while those who rarely read about such topics should be less supportive.

Broader socio-political preferences for EU regulatory policies

Like Gaskell and colleagues, we argue that a person's broader socio-political attitudes and policy preferences should matter greatly in terms of understanding patterns of support and opposition to GM foods. In particular, fundamental preferences for the use of specific agricultural and regulatory policy instruments as well as the overall direction of governmental regulatory institutions can offer an important explanation for the variation in public support for GM foods. In a review essay on consumer acceptance of GM foods, Costa-Font and colleagues (2008) have referred to this as a 'top down' explanation. In this regard, it is presumed that – for a variety of reasons ranging from the politicization of science to issue complexity to individual interest level – consumers are likely to rely on cues emanating from broader policy preferences to determine their attitudes toward GM foods.

In the governance of GM foods, critics continually cite concerns over the democratic governance of GM products and the regulation of such technologies (see Charles, 2001, for examples). Such concerns point to the perceived conflicts of interest between government regulators, agricultural multinationals and consumers. According to Lassen and colleagues (2001: 7):

> From the general public's point of view, the politicians have failed to conduct the necessary debate about the regulatory framework surrounding GM foods. It appears … that public worries have been left in a vacuum between the regulators, who are not providing a satisfactory framework for regulation, and the risk researchers, who are only able to provide a limited degree of certainty.

European experiences with dioxin contamination and BSE served to widely undermine confidence in European regulators and regulatory institutions and threatened to bring domestic health and agriculture regulatory authorities to the verge of crisis. This is important because Lipset and Schneider assert that increased government regulation of industry tends to foster greater conflict between business and government. Interestingly, though, they also point out that 'attitudes toward specific regulations appear almost uncorrelated with people's general feelings about regulation' (1983: 231).

In identifying 'converging lines of evidence' in the literature on GM foods, Scholderer (2005: 269–70) maintains that 'attitudes toward GM foods are strongly related to other, more general socio-political attitudes, including attitudes toward environment and nature.' This contention was perhaps made most strongly in an influential study by Lone Bredahl (2001: 43), who asserts: 'risks and benefits that consumers associate with genetic modification in food production are strongly influenced by a number of more general attitudes, notably attitude to nature, attitude to technology, alienation from the marketplace, food neophobia, and, to a lesser extent, perceived own knowledge about the use of genetic modification in food production.' As a consequence of the genuine uncertainty and the relatively limited nature of debates, it seems intuitive that consumers would rely on broader socio-political preferences to serve as cues in guiding their thinking about the use of GM foods. As Bredahl (2001: 43) surmises: ‘Generally speaking, the more favourable attitudes consumers hold towards nature, i.e., the less consumers believe that man has a right to rule over nature for instance, the more risks do they associate with the use of genetic modification in food production.’

Even within a single issue area such as genetic modification or biotechnology, though, individuals are likely to rely on their own socio-political attitudes to serve as important cues. Cook and colleagues (2006: 6) assert that in the United Kingdom even the phrase ‘GM debate’ ‘proved … to be an ambiguous term, capable of both narrow and broad interpretations.’ Consequently, while the US war in Iraq and the ‘war on terror’ coincided with the media coverage of GM foods during the period of their study, Cook and colleagues (2006: 15) note that respondents tended to ‘conflate the GM issue with other current political concerns of the British press in 2003, specifically Iraq (‘war’), mass migration (‘invasion,’ ‘contamination’ etc.) and terrorism.’ On the other hand, as Bauer (2005b) points out, during the 1990s a veritable red–green divide emerged in European public debates about biotechnology. In such debates, distinctions were made between medical biotechnology (i.e. red) issues and those associated with agricultural biotechnology (green). In noting that attitudes toward the use of GM foods are likely formulated along a number of different dimensions, Bauer’s research (2005b) demonstrates that public perceptions toward green biotechnology issues in Europe turned negative over the course of the 1990s and on the whole were much lower than perceptions associated with red biotechnology. Bonny (2003: 57) captures this logic quite well when describing general perceptions of agricultural biotechnology in France: ‘In France, biotechnology is often seen as an ultimate reinforcement of highly industrialized agriculture that has been the object of more and more criticism in the past few years. It is blamed for deterioration in the quality of foods, damage to the environment, an accelerated reduction in the number of farms, etc.’

Using logic derived from the work of Bredahl and Bonny above, we argue that specific policy preferences regarding the direction of EU agricultural and regulatory policies are likely to help explain respondents’ attitudes toward GM foods. To operationalize our argument about the relationship between agricultural and regulatory policy preferences and support for GM foods, we use two batteries of Eurobarometer questions. The batteries seek to elicit attitudes of respondents in regard to, first, the normative role of agriculture policy in the EU and, second, the extent of EU involvement in areas such as international trade and consumer protection. The batteries of questions are useful because they can be tracked together or independently. For instance, the first battery of questions asks respondents whether the EU should use agricultural policy to promote two different objectives: the competitiveness of European agriculture and promoting methods of organic production. We hypothesize that respondents who feel that agricultural policy should be used to promote the competitiveness of European agriculture will be more supportive of the use of GM foods. Alternatively, we hypothesize that those who feel that the EU should use agricultural policy to promote methods of organic production are naturally going to be less likely to support the use of GM foods. The second battery of questions asks respondents whether the EU should be active or not in each of the two areas listed above (international trade and consumer protection). We predict that the nature of the relationship will be in the same direction in each of these areas when it comes to respondents’ attitudes regarding whether the EU should be active in areas such as trade and consumer protection.

In addition to the three categories of explanation, we insert a series of demographic variables into the model as controls. Specifically, we control for ideology, gender, age, employment status, and whether the respondent’s town is rural to isolate the effects of our variables of interest. By isolating the effects of these factors, we should be able to better assess the explanatory power of our variables of interest.

Model results and discussion

The dependent variable in this study is support for genetically modified food. It is taken directly from responses to the question: '*Could you please tell me if you tend to agree or disagree with the following statement about genetically modified foods?*' Respondents who agreed with the statement 'I do not want this type of food' were coded 0 (i.e. *not* supportive of genetically modified food) and those who disagreed were coded 1. As described above, the model features three classes of explanatory variables – public understanding of science, consumer exposure to media coverage, and socio-political preferences – along with a set of control variables. Details about measurement and descriptive statistics for all variables are reported in the appendix. We employ logistic regression to test the effects of these explanatory factors.[11]

This section reports our logistic regression analysis of support for GM foods. Results for the model with respondents' preferences for GM foods as the dependent variable are displayed in Table 1. The appendix reports both the operationalization and the descriptive statistics for the explanatory variables. The results generally lend strong support for the scientific literacy explanations and mixed support for the second (consumer exposure to media coverage) and third (socio-political preferences) explanations. As reported in Table 1, while the model does not on the whole improve our ability to explain support for GM foods over the modal prediction (owing to the skewed distribution of the dependent variable), many of the individual variables exert significant influences that are consistent with our prior expectations. Logistic regression coefficients are not easily interpreted, and so, following standard suggestions (see, for instance, King, 1989; Liao, 1994), we report first differences, which show the change in probability of support for GM foods associated with a change in each independent variable while others are held constant at their means. Continuous independent variables are varied from one standard deviation below their means to one standard deviation above their means, while categorical variables are varied from the low value to the high value, as indicated in the 'first value' and 'second value' columns in Table 2. To give some indication of the magnitude of the effects of each variable on support for GM foods, Table 2 reports the first differences.

As indicated, the results demonstrate strong support for the scientific literacy explanations described above. The variable *Scientific literacy* has positive, statistically significant effects on support for genetically modified food. In addition, people who consider themselves well informed on science and technology are more likely to support genetically modified foods than are those who consider themselves not well informed. Understanding genetically modified foods likewise has a positive effect on support. In addition to the statistically significant coefficients in the predicted directions for all three of the explanatory variables in this category, Table 2 shows that the marginal effects for each of these variables is around 0.04. First difference results indicate that *Scientific literacy* has the greatest relative impact, 0.0422. In other words, increasing the value of this variable from the lowest score (0) to the highest score (1) while holding all other variables constant at the hold values indicated in the table increases the probability of supporting GM foods by 0.0422. Feeling well informed about science increases the probability of supporting GM foods by 0.0391, and understanding GM food increases the probability of supporting it by 0.0370. Given such results, we find overall support for the assertion by Gaskell and colleagues that scientific literacy is empirically related to individual-level support for GM foods.

Table 1. Logistic Regression Analysis of Support for Genetically Modified Foods
Dependent variable: support for genetically modified food

Theoretical block	Variable	Expected effect	Coeff.	Std. error	Significance level
Public understanding of science	Scientific literacy	+	0.264	0.062	0.000
	Informed re: science	+	0.242	0.065	0.000
	Understand GM food	+	0.239	0.072	0.001
Exposure to media coverage	TV rank	–	0.013	0.022	0.536
	News/mag rank	+	–0.038	0.023	0.095
	Internet rank	+	0.071	0.020	0.000
	Reading frequency (re: science)	+	0.436	0.064	0.000
Socio-political preferences	Agric policy – competitiveness	+	–0.108	0.084	0.201
	Agric policy – promote organic	–	–0.284	0.083	0.001
	EU active international trade	+	0.113	0.097	0.245
	EU active consumer protect		–0.390	0.085	0.000
Demographic controls	Ideology		0.053	0.015	0.001
	Female		–0.459	0.062	0.000
	Age		–0.003	0.002	0.100
	Rural		0.066	0.066	0.313
	Unemployed		0.019	0.142	0.892
	Constant		–1.437	0.252	0.000

Sample size	6942
% correctly predicted	78.90%
% correct, modal prediction	78.70%

Table 2. First Difference Results Regarding Support for Genetically Modified Foods

Theoretical block	Variable	Hold value	First value	Second value	Diff. in prob (support GM food)
Public understanding of science	Scientific literacy	0.490	0	1	0.0422
	Informed re: science	0.415	0	1	0.0391
	Understand GM food	0.706	0	1	0.0370
Exposure to media coverage	TV rank	4.786	3.316	6	0.0057
	News/mag rank	4.158	2.817	5.499	–0.0164
	Internet rank	2.725	1.081	4.375	0.0371
	Reading frequency (re: science)	0.426	0	1	0.0708
Socio-political preferences	Agric policy – competitiveness	0.858	0	1	–0.0176
	Agric policy – promote organic	0.861	0	1	–0.0481
	EU active international trade	0.881	0	1	0.0175
	EU active consumer protect	0.862	0	1	–0.0675
Demographic controls	Ideology	5.160	3.179	7.161	0.0335
	Female	0.482	0	1	–0.0728
	Age	43.740	26.444	60.896	–0.0170
	Rural	0.308	0	1	0.0107
	Unemployed	0.049	0	1	0.0031
	Constant	1	1	1	n/a

The sources of information measured by our second set of explanatory factors (consumer exposure to media coverage) are less indicative of attitudes on GM food, though, as we find mixed support for the four explanatory variables comprising this explanation. First, the importance respondents place on television is not statistically related to support for GM foods. Also, the importance respondents place on newspapers and magazines as sources of information is, contrary to our expectation, negatively related to support for GM foods, although this coefficient is barely significant statistically and the marginal effect on the probability of supporting GM foods is close to zero (–0.0164). Results for the other two variables in this group do support our expectations. Reliance on the Internet is positively associated with support for GM foods, as is frequent reading about science and technology. The marginal effect of *Internet rank* is 0.0371, meaning that as *Internet rank* varies from one standard deviation below its mean to one standard deviation above its mean, the probability of supporting GM foods increases by 0.0371. People who read frequently about science and technology have a 0.0708 higher probability of supporting GM foods than do people who do not read frequently about science, the second largest marginal effect of all of our variables.

We also find mixed support for our expectations concerning the four variables that capture broader socio-political preferences. Preferences related to competitiveness and international trade are not statistically related to support for GM foods. But people who believe that agriculture policy should be used to promote organic methods of production are statistically less likely to support GM foods than are people who do not hold that policy preference. Likewise, people who believe the EU should be active in the area of consumer protection are statistically less likely to support GM foods than are people who do not ascribe to that belief. The marginal effects for each variable are relatively large. The decrease in the probability of supporting GM foods associated with the organic agriculture preference is 0.0481 and the decrease associated with the consumer protection preference is 0.0675.

Although the other variables in the model are included only as controls, it is interesting to note those with significant effects on support for GM foods. *Ideology* has a positive, significant effect on the likelihood of supporting GM foods, which means that the more conservative someone is, all else being equal, the more likely he or she is to support GM foods. The marginal effect associated with a move from one standard deviation below the mean to one standard deviation above for the influence of ideology is 0.0335. *Female* has a statistically significant negative effect on support for GM foods, with the largest marginal effect of any variable in our model. Interestingly, the probability that a woman supports GM foods is 0.0728 lower than the probability that a man supports GM foods when all other variables are held at their means. Finally, *age* has a negative effect on support for GM foods, albeit only significant at the 0.10 level and with a very small marginal effect.[12]

Conclusion

This study attempts to better understand the sources of individual-level variation regarding attitudes toward GM foods across 15 European Union countries. Building on the work of Gaskell and colleagues, this article formed and tested several classes of explanatory factors – including public understanding of science, consumer exposure to media, and broader socio-political preferences – to gauge individual-level sentiment regarding the use of GM foods. The results showed that support for GM foods is positively associated with scientific literacy, specifically captured by one direct measure of literacy as well as self-reported levels of being informed about science and of understanding GM foods. We find that media exposure also matters; specifically, frequent reading about science and the importance of the Internet as a source of information about science are positively associated with support for GM foods. The importance of television is not statistically related to support for GM foods, and the importance of newspapers and magazines has a surprising negative effect. Two of our four indicators of policy preferences have the theoretically expected effects: people who want EU agriculture policy to promote organic methods are less likely than others to support GM foods, as are people who want the EU to be active in the area of consumer protection. In sum, all three classes of explanations show some promise in illuminating the individual basis of judgments on GM foods, most consistently our indicators of scientific literacy.

By utilizing a cross-national, multivariate analysis, this study adds to what is known about attitudes toward genetically modified foods in important ways. First, we confirm in a multivariate analysis a number of hypotheses that have so far been tested only in bivariate settings, and we also provide empirical evidence in support of a number of additional hypotheses. The clearest result is the confirmation that scientific literacy and understanding of GM foods in particular contribute to one's willingness to accept them. Second, we find support for GM foods tied to specific preferences with regard to the use of EU agriculture policy to favor organic production. Also, in the context of one's feelings about the use of EU regulatory institutions, we find an empirical connection between attitudes toward GM foods and the sentiment that the EU should remain active in consumer protection. Our measures of linking preferences for broader policy objectives with support for GM foods may help us to better understand the significance of issue framing – i.e. framing GM foods as an international trade and competitiveness issue, a consumer choice issue, and/or with respect to promoting and protecting public health. In short, the results here affirm some of the previous research cited above and indicate that framing of the political debate over GM foods may go a long way in structuring the nature and outcomes associated with the debate.

The debate over GM food products is particularly fierce across the European continent and there are many reasons for this. First, the trade in agricultural products represents an important political issue in a number of European Union member states. France, Italy, Spain, and Portugal are leading agricultural producers across the continent. Moreover, given that the production of grain, meat, milk, and other produce represents about 4 percent of the European Union's economy, this issue has considerable economic ramifications. Second, the farming sectors in a number of European countries – perhaps most notably in France and Italy – are known for their large number of small farms that have traditionally relied on organic methods. Such farms have long been given considerable agricultural subsidies and such subsidization remains highly concentrated. Among the original 15 EU members, approximately 20 percent of farmers receive 80 percent of the government's agricultural subsidies on the basis of the EU's Common Agriculture Policy (CAP). Thus, it should not be surprising to suggest that disagreements over GM foods may naturally exacerbate rural equity problems by magnifying the contrast between small, privately held organic farms and the larger, corporate biotechnology industry.

Third, the issue of GM foods may eventually form the basis of a growing political cleavage between old and new EU member states. Several of the post-2004 enlargement states, such as Poland, Hungary, and the Czech Republic, represent the largest agricultural states in the EU, and their entry into the multinational union has brought over 10 million farmers into the EU. Yet, as several of these newer EU member states continue to develop adequate GM monitoring, testing and control facilities, continual regulatory challenges are likely to persist. Future research, which considers such attitudes in the post-2004 enlargement and re-evaluates our individual-level hypotheses about attitudes toward GM food, can, by comparison with this pre-enlargement study, say even more than a single cross-sectional study about the impact of different types of media, issue framing, and public awareness of the issue.

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Appendix: variable descriptions and measurements

Dependent variable

Support for genetically modified food
Coded from Eurobarometer question 18-1: "Could you tell me if you tend to agree or tend to disagree with each of the following statements about genetically modified foods?: I do not want this type of food." (1 = tend to disagree, 0 = tend to agree)

Independent variables

Theoretical block	Variable	Measurement	Descriptive statistics (proportions or means and standard deviations)	Eurobarometer question
Public understanding of science	Scientific literacy	0 = incorrect answer to a science qtn1 = correct answer	0: 0.510, 1: 0.490	Q9
	Informed (re: science)	0 = does not feel well informed about science/tech 1 = does feel well informed about science/tech	0: 0.585, 1: 0.415	Q2-4
	Understand (GM food)	0 = does not think understands GM food 1 = thinks understands GM food	0: 0.294, 1: 0.706	Q11-8
Exposure to media coverage	TV rank	Rank importance of TV as source of info about scientific developments: 6 = most important, 1 = least important	mean: 4.786 std. dev.: 1.470	Q5-1R
	News/mag rank	Rank importance of newspapers and magazines as source of info about scientific developments: 6 = most important, 1 = least important	mean: 4.158 std. dev.: 1.341	Q5-3R
	Internet rank	Rank importance of Internet as source of info about scientific developments: 6 = most important, 1 = least important	mean: 2.725 std. dev.: 1.650	Q5-5R

(Continued)

Appendix: (Continued)

Theoretical block	Variable	Measurement	Descriptive statistics (proportions or means and standard deviations)	Eurobarometer question
	Reading frequency (re: science)	0 = rarely read articles; 1 = not rarely read articles (0 = no, 1 = yes)	0: 0.574, 1: 0.426	Q20-5
Socio-political preferences	Agric policy – competitiveness	Should EU use agricultural policy to make European agriculture more competitive? 0 = no, 1 = yes	0: 0.142, 1: 0.858	Q30-2
	Agric policy – promote organic	Should EU use agricultural policy to promote organic methods of production? 0 = no, 1 = yes	0: 0.139, 1: 0.861	Q30-8
	EU active international trade	Should the EU be active or not in the area of: international trade? 0 = not active, 1 = active	0: 0.119, 1: 0.881	Q25-3
	EU active consumer protect	Should the EU be active or not in the area of: consumer protection? 0 = not, 1 = active	0: 0.138, 1: 0.862	Q25-8
Demographic controls	Ideology	Respondent self-placement on 10-point ideological scale: 1 = left, 10 = right	mean: 5.16 std. dev.: 1.991	D1
	Female	0 = male, 1 = female	0: 0.518, 1: 0.482	D10
	Age	Age in years	mean: 43.74 std. dev.: 17.226	D11
	Rural	0 if live in sm or mid-size town or large town; 1 if live in rural area or village	0: 0.692, 1: 0.308	D25
	Unemployed	0 if employed, 1 if unemployed	0: .951, 1: 0.049	D15

Notes

1. From the keynote address to the Conference on Crop and Forest Biotechnology for the Future, organized by the Royal Swedish Academy of Agriculture and Forestry (Falkenberg, Sweden, September 16–18 2001).
2. The Biotechnology Industry Organization (BIO) defines biotechnology as ‘the use of cellular and molecular processes to solve problems or make products.’ Biotechnology products and processes range from human medicines to genetically modified crops to xenotransplantation.
3. For a brief review of the development of public opinion on biotechnology in Europe, see Bauer (2005a).
4. *The Economist* (2010) Taking Root: The Spread of GM Crops, February 27.
5. See Scholderer (2005) for a brief overview of the various phases of European regulation of GM foods.
6. To see the official position of the European Commission regarding the precautionary principle, see European Commission (2000).

7. Other exceptions include Bredahl (2001), Bonny (2003), and Loner (2008).
8. This statement was made by Federico Mayer, then UNESCO Director-General.
9. The hormone (rBST) leads dairy cattle to increase their milk production, and the FDA has asserted that milk produced from cows treated with the hormone is no less safe than milk from cows not treated with the hormone; see Wiener and Rogers (2002) for a review.
10. See Gutteling (2005) for an overview and empirical test of the 'Mazur hypothesis.'
11. As is typical when dealing with survey data, we lose a large number of observations due to missing data. We have no reason to believe that the missing answers are not randomly distributed, however. Hence, we proceed with the study on the basis of this reduced sample as the remaining sample is large enough to perform the analysis.
12. As a methodological note, we estimated a version of our model which included country indicators in addition to the variables listed in the table. Including these variables changes the results for the rest of our variables only slightly. One variable, *Internet rank*, becomes insignificant, and the significance levels of some others change marginally. The values of some other coefficients change when we insert the country variables. The effects of *Scientific literacy* and *Reading frequently about science* become smaller, though they are still positive and significant. The effect of *EU active on consumer protection* is diminished, though still negative and significant. Being well informed about science has an even bigger effect in this specification than in the model reported in the table.

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