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Trust and Distrust in Biotechnology Risk Managers: Insights from the United Kingdom, 1996-2002

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During the late 1990s, negative events related to biotechnology were reported in the UK media. According to the trust asymmetry hypothesis, such events should cause public trust in biotechnology risk managers to decline rapidly and rebound slowly. Using *Eurobarometer* data we show that public trust in risk managers declined from 1996 to 1999 but rebounded sharply between 1999 and 2002. Using canonical discriminant analysis we find that trust is correlated with knowledge of science, as well as perceptions of benefits and risks. We also identify distinct categories of people who do not trust—people who distrust risk managers but trust other sources of biotechnology information, people who trust nobody, and people who are uncertain about their trust of risk managers. We argue that attention should be placed not only on understanding how to improve trust but also on the nature and characteristics of people who distrust risk managers of biotechnology.

Key words: biotechnology, distrust, knowledge of science, public support, public trust, risk managers.

Introduction

On March 20, 1996, the British government announced that scientists had discovered a new variant of Creudzfeldt-Jakob disease, which had infected ten young victims. Importantly, scientists could not rule out a link with the consumption of beef from cattle infected with bovine spongiform encephalopathy (BSE). The announcement led to a drop in consumption of British beef by 40% (DTZ Pieda Consulting, 1998). Some observers argued that the 1996 announcement "shattered any remnants of credibility enjoyed by the British government" (Powell & Leiss, 1997, p.11) because BSE had been discovered in the British beef herd ten years earlier, over which time the British public was exposed to the infectious prions believed to cause BSE. Although the BSE episode is not directly related to the genetic modification of crops and foods, some have concluded that it contributed to a general climate of "extreme mistrust" of the UK Ministry of Agriculture, Food and Fisheries (Powell & Leiss, 1997). Such a climate of distrust could affect perception of subsequent technological developments, such as biotechnology.

Following the 1996 BSE announcement, there were a series of other alleged food and environmental safety events directly linked to biotechnology and highly reported in the UK media (Marks, Kalaitzandonakes, Allison, & Zakharova, 2003). For instance, in 1998 Dr. Arpad Pusztai publicly stated that biotech potatoes fed to laboratory rats had caused severe damage to their organs and overall development. In 1999, John Losey and colleagues published a study suggesting that North American Monarch butterflies could be harmed by biotech corn pollen, which garnered international media attention. In May 2000, genetically modified canola seeds not approved for commercialization in European markets were found in imported conventional varieties and unknowingly planted by UK farmers, an incident that was also highly reported by the UK media.

The relationship between public trust and reported events, such as those described above, is important because scholars have argued that trust in risk managers is a key factor in public perception and acceptance of complex technologies, such as biotechnology (Kasperson, Kasperson, Pidgeon, & Slovic, 2003; Siegrist & Cvetkovich, 2000; White & Eiser, 2005). We are therefore interested in understanding how these and similar media events are correlated with public trust of biotechnology risk managers over time. We define risk managers as those persons or entities responsible for the development and control of biotechnology, including industry (which develops and utilizes biotechnology), universities (which conduct research leading to potential technological breakthroughs), and governments (which regulate biotechnology). Because these events center on the late 1990s, we examine data from the 1996, 1999, and 2002 waves of the *Eurobarometer* (European Commission, 1997, 2000, 2003), which fortunately naturally bracket the peak in media coverage of risk events asso-

Table 1. Definitions of variables and summary statistics.

	Eurobarometer year		
Variables	**1996**	**1999**	**2002**
Risk managers			
Percent of respondents who trust industry	4.60	3.17	5.53
Percent of respondents who trust universities	28.61	26.73	44.55
Percent of respondents who trust government	14.16	10.24	13.11
TRUST: Percent of respondents who trust industry, universities (scientists), or government (i.e., biotechnology risk managers)	40.19	34.39	50.30
DISTRUST: Percent of respondents who distrust industry, universities, and government, but trust other sources of information	49.89	56.63	33.48
NONTRUST: Percent of respondents who do not trust any sources of information	2.59	1.10	9.55
UNCERTAIN: Percent of respondents indicating uncertainty (i.e., "don't know") about trust of sources of information	7.33	7.88	6.67
Explanatory and control variables			
Percent who believe biotechnology or genetic engineering will improve life	47.23	31.00	32.42
Percent who definitely agree or tend to agree that using biotechnology in food production or transferring genes fromplants to crops is too risky	72.03	56.48	50.30
Average of 3 age categories of when respondent finished fulltime education, where 1=0-15 years, 2=16-19 years, and 3=20 and older	1.95	1.87	1.93
Average of nine science questions that respondents answered correctly	5.32	4.82	5.25
Percent indicating they have ever talked about biotechnology	44.43	38.29	35.53
Percent male	47.02	46.17	45.15
Average of 6 age categories, where 15-24=1; 25-34=2; 35-44=3; 45-54=4; 55-64=6; and 65 and older=6	3.38	3.40	3.43
N	1391	1358	1320

Source: Eurobarometer (1996, 1999, 2002), United Kingdom only.

ciated with food and crop biotechnologies (Marks et al., 2003). According to the data, the percent of respondents who had confidence (our measure of trust) in risk managers of biotechnology declined from 40.19% in 1996 to 34.39% in 1999, but it increased to 50.30% in 2002. We also observe a decline in public trust for each category of risk manager (industry, universities, and government) from 1996 to 1999 but an increase of trust in 2002 (Table 1). These observations are important because while a decline in public trust from 1996 to 1999 is predicted, the rebound in trust by 2002 is unexpected. Some scholars argue that negative risk events not only will be "trust-destroying," but the effect should also be asymmetric in the sense that trust is easier to destroy than it is to create (Slovic, 1993). Slovic and others have argued that negative or trust-destroying events are often more visible than trust-creating events, are more highly reported therefore, and they are also usually perceived as being more credible than positive ones (Siegrist & Cvetkovich, 2001; Slovic, 1993).

Although the idea of trust asymmetry is recognized in the literature, "there has been relatively little empirical research on trust asymmetry" (White & Eiser, 2005, p. 1187). The purpose of this article is to provide some insight into the pattern of trust observed in the 1996, 1999, and 2002 waves of the *Eurobarometer* by considering the possibility that distrust of biotechnology risk managers might not imply an unwillingness to trust generally. That is, some people might trust no group or individual (i.e., they are nontrusters), while others might only distrust risk managers and simultaneously trust non-risk manager entities or organizations (such as consumer groups or the media) with respect to information or reports about biotechnology (i.e., they are distrust-

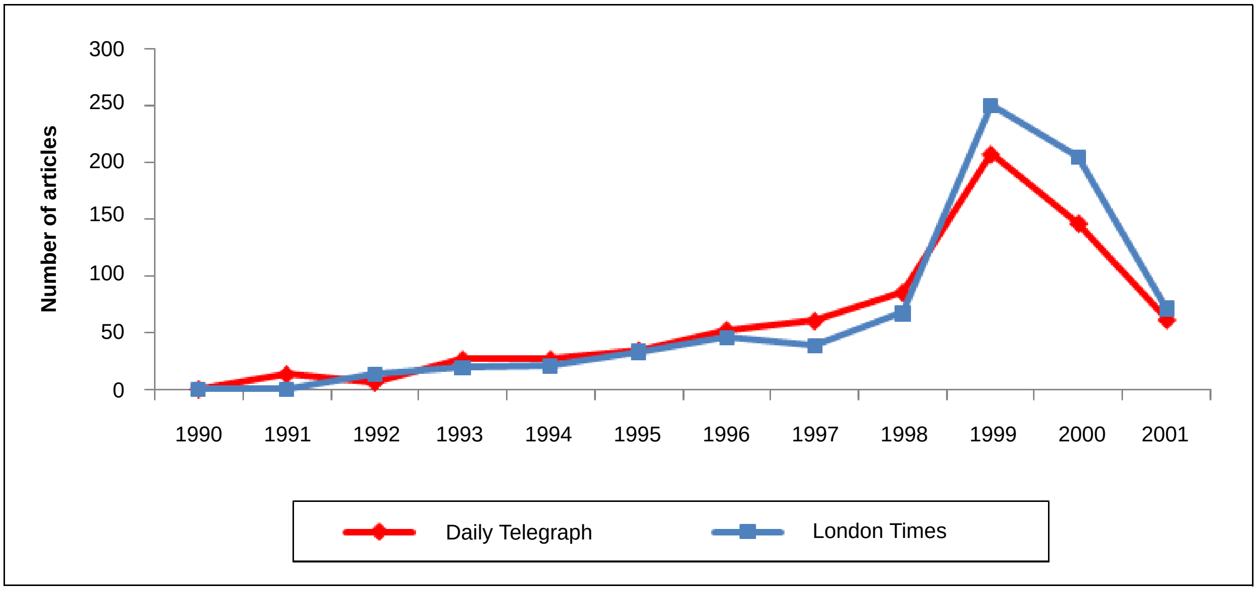

Figure 1. Media coverage of agbiotech in UK newspapers, 1990-2001.
Source: Marks and Kalaitzandonakes (2001).

ers). In order to distinguish among different categories of trust, we use canonical discriminant analysis to model the effect of factors expected to affect public trust in risk managers for each of the three waves of the *Eurobarometer* survey. We find that specific knowledge of science, generalized knowledge, and perceived risks and benefits are important factors explaining trust in biotechnology risk managers, although specific knowledge of science is the most important factor. We also find that people who do not trust risk managers are not a homogeneous group, with nontrusters being the group exhibiting the largest change from 1996 through 2002.

Patterns of Negative Media Events in the United Kingdom

The BSE, Pusztai affair, monarch butterfly, and GM commingling episodes highlight the nature of media events that occurred in the United Kingdom during the mid- to late 1990s. Importantly, these events coincide with an increase in the quantity of media coverage of agbiotech events in the UK throughout the 1990s, which peaked in 1999 (see Figure 1, reproduced from Marks & Kalaitzandonakes, 2001). Negative framing of agbiotech news also peaked during 1999, with coverage turning more positive post-1999 (Marks et al., 2003; Marks, Kalaitzandonakes, Wilkins, & Zakharova, 2007). These negative frames have been driven by events that either signaled a *potential* risk or government inability to effectively manage and regulate the technology. Importantly, no actual health and biosafety risks from biotechnology have been realized.

If negative media coverage impacts trust, then according to the asymmetry hypothesis, public trust in biotechnology risk managers should decline from 1996 to 1999; that is, increasing distrust of risk managers is predicted. This finding is observed in the data. However, if such effects are asymmetric—trust declines rapidly but rebounds more slowly—then the observed increase in reported public trust of UK risk managers between 1999 and 2002 is unexpected. In order to shed further light on this observation, the nature and characteristics of public trust need more careful examination. What follows is a discussion of factors that are expected to correlate with trust and distrust in order to further motivate our empirical analysis and findings.

Public Trust and Risk Perceptions

Although there are many ways of defining trust (Hardin, 2001), we conceptualize trust as an expectation regarding the behavior or intentions of others and assert that for trusting behavior to have meaning, it must create a personal vulnerability for the trustor (see, for instance, James, 2002a; Mayer, Davis, & Schoorman, 1995; Nooteboom, 2002). There are two possible temporal sequences in which trusting expectations arise. The first is when a trustor moves *first* by taking a vulnerable action that is either honored or exploited by another. The second is when a trustor moves *second* by taking a vulnerable action relying on the initial statement or action of another. In either case, if people create a vulnerability for themselves by trusting, then they ought to have "good grounds" for doing so (Baier, 1986). If people need "good grounds" for trusting (or, conversely, for distrusting), then what are those grounds? What reasons might exist for someone to trust or distrust? Fundamentally, these reasons are often rooted in the expectation of *trustworthiness* of the person or entity in whom trust is placed (James, 2002a). Expectations of trustworthiness reflect two distinct components—perception of the motives, incentives, or goodwill of those in whom trust is placed, and perception of their competence or dependability (Barber, 1983; Das & Teng, 2004). For instance, Baier (1986, p. 240) states that "we trust [others] to use their discretionary powers competently and nonmaliciously" and Hardin (2004, p. 8) says that "trust depends on two quite different dimensions: the motivation of the potentially trusted person (or institution) to attend to the truster's interests and his or her competence to do so." If either of these two elements of trustworthiness is lacking, then we would not expect there to be trust. Moreover, there is an important distinction between perceptions of *goodwill* and perceptions of *competence* when understood within the context of intention. A person who intends to exploit a person's trust should not be trusted, but, then neither should a person who would unintentionally do so. We would say a person shows goodwill if they do not intend to exploit another's trust, while a person is competent if they would not unintentionally exploit another's trust.

The literature on public trust and support for biotechnology is consistent with this general conceptualization of how expectations of goodwill and competence affect trust (James, 2003, 2006), although the temporal sequence of trust is generally of the second type, where a trustor (e.g., the public) moves second by relying on others (e.g., the statements of biotechnology risk managers). According to the literature, the public perceives that institutions responsible for the development, use, and regulation of biotechnology face two biases—a *reporting bias*, which is an incentive to overstate benefits and understate risks, and a *knowledge bias*, which is an inability to fully anticipate all contingencies—when publicly communicating the risks and benefits of biotechnology research (Eagly, Wood, & Chaiken, 1978; Peters, Covello, & McCallum, 1997; Renn & Levine, 1991). The *reporting bias* aligns with the notion of perceived goodwill, whereas the *knowledge bias* aligns with the notion of perceived competence. When the public perceives that institutions responsible for the development, use, and regulation of biotechnology face a significant reporting bias or knowledge bias, they may have "good grounds" to distrust those institutions because of how these biases translate into perceived incentives to behave less than honorably or to behave incompetently, respectively. Quite simply, if the public distrusts biotechnology risks managers, they may not take the vulnerable action of eating foods that risk managers say are safe.

Expectations of trustworthiness (goodwill and competence) are not the only factors expected to affect trust, however. One also has "good grounds" for trusting when one believes that doing so will result in some benefit or gain. For example, Baier (1986, p. 236) asks why we trust, or "why we typically do leave things that we value close enough to others for them to harm them." Her answer is simply "that we need their help." In other words, we trust when we need and expect some gain when our trust is correctly placed. Consequently, the greater a person's expected benefits from correctly trusting, the more likely he or she will trust, other things being equal. Conversely, one has "good grounds" not to trust—that is, to distrust—if one believes that the expected losses from mistrusting are too large. Mistrusting means incorrectly placing trust in someone who has a strong incentive to exploit that trust or who is incompetent. Thus, the lower the expected losses are from mistrusting, other things being equal, the more likely a person would be willing to trust. Expected goodwill and competence, expected gains from correctly trusting, and expected losses from mistrusting jointly form key elements affecting the likelihood that trust will exist (James, 2002b). When people perceive that others are honorable and competent, and when the expected benefits from trusting are large enough relative to the expected losses from mistrusting, then they have "good grounds" to trust others. However, "good grounds" does not equate with "certainty." Expectations of large benefits, low costs, and trustworthiness are necessary but not sufficient conditions, meaning their presence does not guarantee the existence of trust. Expectations of small or negligible benefits, high costs, and untrustworthiness, on the other hand, would be expected to reduce trust and even cause distrust.

Like trust generally, public trust is also affected by perceptions of trustworthiness, as well as by perceptions of the expected benefits from correctly trusting and expected losses from mistrusting (James, 2002b, 2003, 2006; Peters et al., 1997). These perceptions in turn can be affected by how risks (and benefits) are communicated through framing of hazard events (Eagly et al, 1978; Slovic, 1993). Because framing matters, and because expectations of benefits relative to costs and trustworthiness are necessary but not sufficient for trust, many observers have argued that public trust is fragile (Kramer, 1999) and exhibits an asymmetry (Slovic, 1993) in the sense that trust is difficult to gain but relatively easy to lose (Barber, 1983; Dasgupta, 1988; Levi, 1998; Rempel, Holmes, & Zanna, 1985). Moreover, while trust in close interpersonal relationships can be resilient to negative events (Murray, Bellavia, Rose, & Griffin, 2003), in the case of public trust, Slovic (1993) suggests that once trust begins to decline, negative information can hold more weight than positive information in decision-making over time. A negativity bias in trust related information occurs because negative information is generally easier to imagine or is more mentally available than positive information (White & Eiser, 2005). A negativity bias might also exist if people don't explicitly think about whether or not they trust until something bad happens—that is, if trust is implicit (see Meijboom, 2007). People also perceive negative information as more credible than positive information (Siegrist & Cvetkovich, 2001). Trust suffers from a negative downward spiral whereby trust turns to distrust and distrust leads to withdrawal and ever greater distrust (Yamagashi, 2001). These findings might explain why trust in UK biotechnology risk managers declined from 1996 to 1999, but they do not explain the observed increase in trust from 1999 to 2002.

One possible explanation is suggested by White, Pahl, Buehner, and Haye (2003) and Poortinga and Pidgeon (2004), who postulate that a confirmatory bias might moderate reception of risk information. According to this hypothesis, prior beliefs and attitudes influence how people react to media events. Events consistent with prior beliefs confirm attitudes while events inconsistent with prior beliefs are discounted. Hence, people who are generally supportive of biotechnology and trusting of biotechnology risk managers may be less influenced by negative coverage than people opposed to biotechnology. However, the knowledge that people possess can also influence information processing and thus impact public acceptance of biotechnology (Savadori et al., 2004), although not all scholars agree that scientific knowledge improves trust or public support (Priest, 2000). Because lay publics do not always have a strong understanding of basic science, especially in the context of biotechnology (Durant, Bauer, & Gaskell, 1998; Miller, 1998), people may not have the capability to interpret correctly media messages regarding risks and benefits of biotechnology (Siegrist & Cvetkovich, 2000). In this case, people will have a need to trust scientists and other experts (Meijboom, 2007). Indeed, there is evidence that public trust of scientists is relatively high (James, 2006; Lang & Hallman, 2005). Hence, the direction of causality might be as follows: If people have little knowledge of science, then they will need to trust experts (e.g., scientists); if people trust scientists, then they will perceive fewer risks and more benefits from biotechnologies if scientists and other risk managers make positive reports about the technology. This suggests that there should be a negative correlation between the knowledge people possess and public trust in scientists and other risk managers.

The problem with this explanation is that it leaves open the question of whether low-knowledge persons are *more* likely to trust than persons with adequate knowledge. It could be that people who are highly educated or have significant knowledge of science will have a basis to perceive whether statements and actions of experts are reasonable; that is, they may be in a position to make judgments on the credibility of experts. In this sense, public trust might be positively correlated with generalized knowledge and knowledge specific to science. In this context, generalized knowledge represents a broad education that may include knowledge of science, while knowledge specific to science refers to a correct understanding of scientific principles, especially those relating to genetics and biotechnology. If trust is positively correlated with knowledge, then knowledge might be a moderating factor of the trust asymmetry hypothesis. And, if people with knowledge have prior tendencies to accept biotechnologies, then any negative reactions they might have to negative media reports might not be lasting. We expand the literature on trust and trust asymmetry by examining not only how trust changes over time as a result of informational events but also how factors relating to trust, particularly measures of knowledge, affect trust over time.

We also consider the possibility that respondents who do not trust risk managers might not be a homogeneous group. Studies typically either dichotomize trust into *trust* and *no trust* (e.g., James, 2003, 2006) or model trust as having either increased or decreased (e.g., Poortinga & Pidgeon, 2004; Slovic, 1993; White & Eiser, 2005). However, we conjecture that respondents who have little or no trust in risk managers may trust other entities (i.e., they show *distrust* toward risk managers), or they may not trust any entity (i.e., they exhibit *nontrust*). Moreover, people who "don't know" whether they trust risk managers may not be the same as people who simply do not trust anyone, the difference being that survey respondents indicating "don't know" tend to be less informed than those who are unwilling to trust (see Faulkenberry & Mason, 1978). As we show below, an examination of factors expected to be correlated with trust and how they relate to different categories of trust (e.g., trust, distrust, nontrust, and uncertainty, as defined in Table 1) provides insight into the finding that public trust in risk managers increased after a decline seemingly caused by negative media events.

Analysis

We use data from the 1996, 1999, and 2002 waves of the *Eurobarometer* to examine factors expected to correlate with trust in order to explain how trust-eroding events might affect trust. We focus on the United Kingdom only because the BSE, bovine growth hormone, Pusztai affair, Monarch butterfly, and biotech commingling events are pertinent to the UK.

In each wave of the *Eurobarometer*, respondents were asked how much confidence they have in various organizations to "tell the truth about modern biotechnology."[1] The list of organizations includes industry, universities, government,[2] and other non-governmental, political, and special interest organizations. Respondents were given an option of indicating whether they have confidence in each of the listed organizations. We use *confidence* as our indicator of public trust in risk managers. If respondents indicated that they had confidence in industry, universities, or national governments, then we defined that person as exhibiting *trust* in risk managers. If respondents did not indicate trust in industry, universities, or government, then we defined the following variables: (a) respondents exhibited *distrust* if they did not indicate any confidence in any of the three groups risk managers but did place confidence in other organizations, such as consumer or environmental interest groups or religious organizations; (b) respondents exhibited *nontrust* if their response to which organizations they had confidence in was "none of the above," or (c) respondents are *uncertain* if they indicated "don't know." We distinguish between *nontrust* (i.e., "no opinion") and *uncertain* (i.e., "don't know") because research suggests these are distinct categories (Faulkenberry & Mason, 1978). People who respond with "no opinion" generally do so from a rational, informed state. In contrast, "don't know" often indicates a degree of ignorance on the subject. Table 1 presents definitions and means for these as well as for other variables used in our analysis.

In order to provide a meaningful comparison across time, we are constrained by the need to use the "same" explanatory variables for each year. Unfortunately, the *Eurobarometer* does not always ask the same questions in each wave of the survey. Therefore, our list of explanatory and control variables is limited. Because trust is a function of expectations of benefits relative to costs (James, 2002b), at a minimum we need information on respondent perceptions of risks and benefits. Fortunately, we were able to construct a measure of perceived benefits and risks based on a set of common questions across all three waves of the *Eurobarometer*. Perception of benefits was derived from the percent of respondents who believe biotechnology or genetic engineering will result in an improvement of life. Perception of risk was derived from the percent of respondents who "agree" or "tend to agree" that using biotechnology in food production or in the transferring of genes from plants to crops is too risky (see Table 1). In order to test the relationship between generalized knowledge and knowledge of science and trust, we include a variable indicating how old respondents were when they completed their fulltime education and a variable constructed from the total number of basic science and genetics questions respondents answered correctly (out of 9 possible answers). We assume that the older a person was when he/she completed fulltime education, the greater is the generalized knowledge. We also assume that the more science and genetics questions respondents answer correctly, the greater is their knowledge of science.[3] As controls we include variables representing how frequently respondents talk about biotechnology as well as the respondent's age and gender.

We observe that public trust in risk managers declines while distrust increases between 1996 and 1999, but trust increases and distrust declines between 1999 and 2002. These changes are significant at the 5% level or better in difference of means test. The decline in public trust from 1996 to 1999 is expected as media attention on negative biotechnology events increased during this time period, peeking in 1999 (see Figure 1). Although trust in each type of risk manager (industry, universities, and governments) declines between 1996 and 1999 (Table 1), the change is significant for govern-

1. *It is important to recognize the limitation of this question for our study. "Biotechnology" is a broader concept than biotech foods and crops and is liable to invoke other kinds of applications, including medical ones.*
2. *In 1996, the option presented to respondents was "public authorities." In 1996 and 2002, the term "national government bodies" was used instead.*

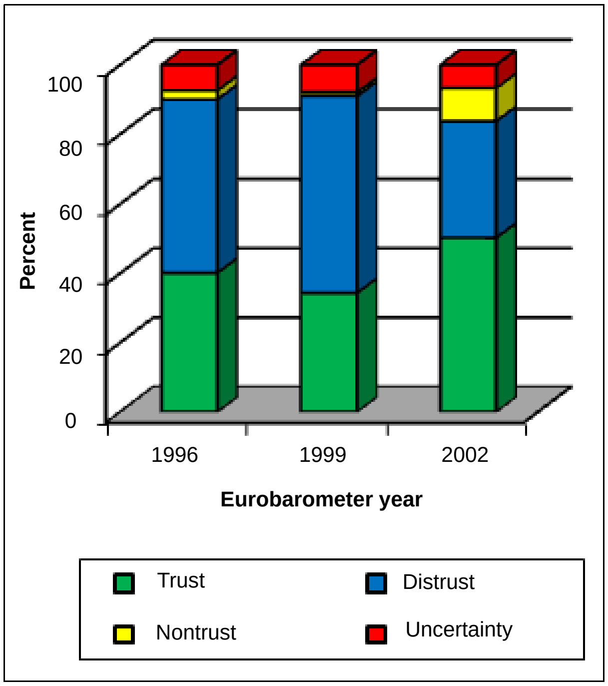

Figure 2. Percent of survey respondents from the United Kingdom reporting trust, distrust, nontrust, and uncertainty with respect to risk managers of biotechnology in 1996, 1999, and 2002.

Source: Eurobarometer (1996, 1999, 2002), United Kingdom only.

ment only. However, trust increases between 1999 and 2002 for each of these categories, albeit strongly only in the case of universities. Furthermore, of the three types of risk managers, respondents trust universities most, followed by government, and finally industry. This pattern is consistent with previous research (Lang & Hallman, 2005).

Figure 2 reveals patterns of trust and distrust in biotechnology risk managers for 1996, 1999, and 2002. First, in 1996 and 1999, distrustors of risk managers are the largest percentage group, with more than half of respondents on average expressing distrust in biotechnology risk managers but trust in other sources of biotechnology information (our definition of "distrust"). However, in 2002, one-half of all respondents indicate at least some trust in risk managers. Second, the percent of respondents who express uncertainty with respect to public trust is relatively stable across all three waves of the *Eurobarometer*, averaging approximately 7% of all respondents in each of the three waves of the study. Third, the percent of respondents who are nontrusters (i.e., those who don't trust any source of biotechnology information) is very small in 1996 and 1999. However, the largest change is in this category of respondents. Specifically, while 1-3% of respondents placed no trust in any source of biotechnology information in 1996 and 1999, nearly 10% of respondents were classified as nontrusters in 2002, a significant 768% increase between 1999 and 2002. Thus, it appears that after the peak in media coverage in 1999, some distrustors of risk managers may have become trustors while others became nontrustors, a category of distrust that was virtually unimportant in 1996 and 1999. Are nontrusters distinct from people who distrust or are uncertain regarding their trust of biotechnology risk managers? If so, what might affect this pattern of trust we identify?

In order to determine the extent to which people who do not trust risk managers are not a homogenous group, and in order to understand what factors distinguish among respondents who trust or do not trust risk managers, we perform a canonical discriminant analysis of the data using categories of trust, distrust, nontrust, and uncertainty as the dependent variable. Our objective is to determine which variables expected to affect trust discriminate among the four categories of trusting. The canonical discriminant procedure finds coefficients for the linear combination of explanatory and control variables that best separates or distinguishes among each of the categories of a dependent variable (in this case, the four possible trusting states). It does this K-1 times, thereby creating K-1 orthogonal discriminant functions, where K is the number of categories, such that the first discriminant function provides the best overall discrimination among the groups, the second function provides the second best discrimination, and so forth. We use canonical discriminant analysis rather than logistic regression because we cannot, *a priori*, assign a rank order to these four trusting categories. For example, if we could rank the categories hierarchally, such as trust, distrust, nontrust, and uncertainty, then we could con-

3. *The following are the science questions common to each year of the Eurobarometer. Respondents were asked to indicate whether the statement is true or false: 1. There are bacteria which live from waste water (true); 2. Ordinary tomatoes do not contain genes, while genetically modified tomatoes do (false); 3. The cloning of living things produces genetically identical copies (true); 4. By eating a genetically modified fruit, a person's genes could also become modified (false); 5. Yeast for brewing beer consists of living organisms (true); 6. It is possible to find out in the first few months of pregnancy whether a child will have Down's Syndrome (true) 7. Genetically modified animals are always bigger than ordinary ones (false); 8. More than half of human genes are identical to those of a chimpanzee (true); and 9. It is not possible to transfer animal genes into plants (false).*

Table 2. Correlation coefficients between measures of public trust in biotechnology risk managers and primary explanatory variables.

	Believe biotech will improve life	Believe biotech is risky	Age ending education	Knowledge of science
***Eurobarometer* year 1996**				
Trust industry	**0.060**	-0.039	0.043	0.032
Trust scientists	**0.086**	-0.027	**0.146**	**0.118**
Trust government	**0.107**	0.014	-0.022	0.020
Trust	**0.123**	-0.015	**0.103**	**0.099**
Distrust	**-0.062**	**0.058**	-0.022	-0.000
Nontrust	-0.045	0.001	0.004	0.010
Uncertainty	**-0.083**	**-0.083**	**-0.154**	**-0.192**
***Eurobarometer* year 1999**				
Trust industry	0.042	**-0.062**	0.004	0.022
Trust scientists	**0.146**	0.027	**0.124**	**0.191**
Trust government	**0.105**	-0.032	0.047	0.026
Trust	**0.152**	0.026	**0.122**	**0.176**
Distrust	**-0.123**	0.044	**-0.054**	-0.039
Nontrust	0.021	0.036	0.010	0.013
Uncertainty	-0.048	**-0.140**	**-0.119**	**-0.243**
***Eurobarometer* year 2002**				
Trust industry	**0.094**	0.008	-0.021	**0.054**
Trust scientists	**0.167**	0.046	**0.156**	**0.203**
Trust government	**0.124**	-0.014	**0.110**	**0.102**
Trust	**0.177**	0.042	**0.169**	**0.214**
Distrust	**-0.097**	0.005	**-0.076**	**-0.074**
Nontrust	**-0.054**	-0.002	**-0.103**	**-0.073**
Uncertainty	**-0.107**	**-0.093**	-0.074	**-0.203**

Bold indicates significant at 5% or better.
Source: Eurobarometer (1996, 1999, 2002), United Kingdom only.

duct a logistic regression analysis to determine how explanatory variables are correlated with trust. However, we have no basis to rank the categories in this way. Canonical discriminant analysis has the added advantage of determining whether the categories identified are in fact distinct categories. Are those who trust risk managers distinct in a meaningful way from those who distrust, have no trust, or who express uncertainty with respect to the question of trusting biotechnology risk managers? If so, what explanatory variables can account for the distinctness? Canonical discriminant analysis provides insight into these questions as well as our observation that public trust in risk managers during the 1996 to 2002 period does not conform to the trust asymmetry hypothesis.

Table 2 presents correlation coefficients among the perceived benefits, risk, generalized knowledge, and knowledge of science variables and the trust measures. Importantly, expected benefits of biotechnology is positively correlated with trust and negatively correlated with distrust and uncertainty for each of the three *Eurobarometer* years. There is also a positive correlation between both knowledge variables and trust in risk managers, and a negative correlation between the knowledge variables and respondents expressing either distrust of risk managers or uncertainty. Both knowledge questions are also highly and positively correlated with trust in scientists. Interestingly, the correlation of explanatory variables and the nontrust variable reverses signs and significance across the three waves of the *Eurobarometer.*

Table 3. Results of canonical discriminant analysis of factors expected to affect public trust, distrust, nontrust, and uncertainty with respect to biotechnology risk managers in the United Kingdom, in 1996, 1999, and 2002.

Variables and diagnostic tests	Function 1	Function 2
***Eurobarometer* year 1996**		
Believe biotech will improve life	0.315	0.662
Believe biotech is risky	0.181	-0.552
Age ending education	0.402	0.108
Knowledge of science	0.501	-0.337
Talked about biotechnology	0.279	-0.117
Male	0.230	0.315
Age category	0.098	0.038
Eigenvalue, (prob)	0.074	0.011
Canonical correlation	0.263	0.104
Squared canonical corr	0.069	0.011
Wilke's Lambda	0.917	
F stat (d.f.=21), (prob)	5.74 (<.0001)	
***Eurobarometer* year 1999**		
Believe biotech will improve life	0.225	0.763
Believe biotech is risky	0.197	-0.588
Age ending education	0.248	0.271
Knowledge of science	0.692	-0.258
Talked about biotechnology	0.199	0.095
Male	0.193	0.093
Age category	-0.014	0.215
Eigenvalue, (prob)	0.107	0.018
Canonical correlation	0.311	0.134
Squared canonical corr	0.097	0.018
Wilke's Lambda	0.886	
F stat (d.f.=21), (prob)	7.95 (<.0001)	
***Eurobarometer* year 2002**		
Believe biotech will improve life	0.431	-0.247
Believe biotech is risky	0.132	0.433
Age ending education	0.415	-0.622
Knowledge of science	0.681	0.371
Talked about biotechnology	0.033	0.221
Male	-0.115	0.051
Age category	0.203	0.277
Eigenvalue, (prob)	0.116	0.010
Canonical correlation	0.322	0.101
Squared canonical corr	0.104	0.010
Wilke's Lambda	0.885	
F stat (d.f.=21), (prob)	7.75 (<.0001)	

Source: Eurobarometer (1996, 1999, 2002), United Kingdom only.

Table 3 presents the results of the canonical discriminant analysis. Because there are four categories of trust, the procedure calculates three discriminant functions. We report only the results for the first two functions because the third function in each year is not significant. In order to show the relative importance of the variables in the discriminant functions, we report standardized coefficients. Initially examining the squared canonical correlation, we find that the explanatory variables explain 7% (in 1996) and 10-11% (in 1999 and 2002) of the variation in the dependent variable (trust categories). Although this is not large, overall F-statistics are significant for the model in each of the three years, suggesting that the discriminant model is able to distinguish among categories of trust.

An examination of the size of the standardized coefficients reported in Table 3 reveals that specific knowledge of science is the dominant variable in the first discriminant function for each of the three years of data, meaning that knowledge of science is the most important variable for discriminating or distinguishing among the different categories of trust. Generalized knowledge, measured by the age (category) at which respondent ended fulltime education, as well as a belief that biotechnology will improve life, are also relatively important in 1996 and 2002, but they are relatively unimportant in 1999. The effect of perceived risk is always relatively small. In the case of the second discriminant function, the explanatory variables explain only 1-2% of the variability in the function across each year, suggesting that it is substantially less important than the first function. Within this function, perceptions of risks and benefits are most responsible for discriminating among the categories of trust for years 1996 and 1999, while in 2002 the most important factors are generalized knowledge and perceived risks. Respondent age and gender, as well as having talked about biotechnology, are relatively unimportant in discriminating among the categories of trust.

The mean values of the group centroids for each function are plotted in Figure 3. Plotting the group centroids provides a visual means of determining the extent to which the hypothesized categories of trust are distinct and affected by the explanatory variables. Consider initially the first function (horizontal axis of each graph in Figure 3). Because this function is dominated by the variable representing knowledge of science, the positive coefficient of that variable means that an increase in science knowledge corresponds to a movement to the right along the horizontal axis of the discriminant function plotted in panels (a), (b), and (c) of Figure 3. In particular, moving from relatively low to higher levels of basic science knowledge corresponds to a change in trust categories from uncertainty to nontrust and distrust and then to trust. In other words, respondents with relatively little knowledge of science are correlated with respondents expressing uncertainty when asked about how confident they are in risk managers; respondents with relatively high levels of knowledge of science seem to be more likely to trust risk managers than to express distrust, nontrust, or uncertainty. For example, in 1996 the average number of science questions correctly answered by people who trust biotechnology risk managers was 5.59 (the largest of the four trust categories in 1996), while the average for the uncertain group was 4.01 (the smallest of the four categories), a statistically significant difference ($p < 0.000$). In 1999 and 2002, the science knowledge gap between trusters and those who were uncertain widened so that trusters answered on average two more science questions correctly compared to uncertain respondents. Respondents with a moderate knowledge of science either distrusted risk managers or expressed no trust in any organization, with a statistically significant difference in knowledge of science showing in 2002 only (5.04 questions correctly answered by distrusters and 4.79 correctly answered by nontrusters). Interestingly, the effect science knowledge has on distrust and nontrust changes over time. In 1996 there is no significant difference between the categories of distrust and nontrust (see Function 1 of the first panel of Figure 3). In 1999, as shown in panel (b) of Figure 3, however, these categories become distinct along the first discriminant function, while in 2002 the distinctness remains but the relative position reverses. Thus, in 1999 the distinction between distrusters and nontrusters becomes salient, with nontrusters emerging as a distinct group in 2002 of people who don't trust risk managers.

Within the second discriminant function we observe only a distinction between trust and uncertainty on the one hand, and distrust and nontrust on the other hand. This function is dominated largely by perceptions of risks and benefits associated with biotech foods, except in 2002 the second function is dominated by generalized knowledge (proxied by respondent age when concluded education). Given the signs on the coefficients of these variables, we find that increases in perceived benefits, decreases in perceived risks, and increases in the age respondents finished education result in respondents becoming less likely to distrust or be nontrustors of risk managers. Interestingly, these factors do not necessarily result in trust but in respondents who are either trusters or uncertain regarding their trust of risk managers. Since

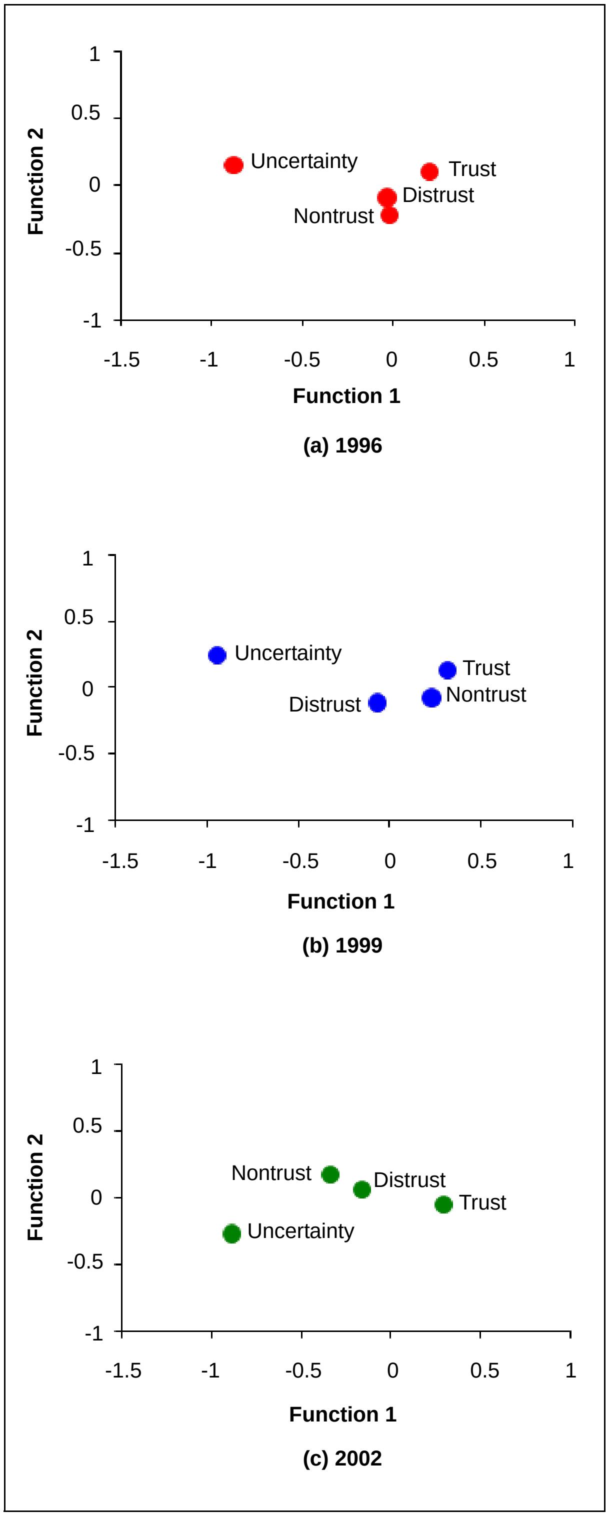

Figure 3. Location of group centroids from discriminant function analysis of trust, distrust, nontrust, and uncertainty in the United Kingdom in 1996, 1999, and 2002.

the second discriminant function neither distinguishes between trust and uncertainty, nor does it distinguish between distrust and nontrust, it appears that a key reason why some people trust while others are uncertain rests on the amount of specific scientific knowledge respondents have, as indicated by the first discriminant function. Perceptions of risks and benefits may play a small supporting role, but perceptions alone may not be sufficient in determining whether or not there is trust in biotechnology risk managers.

Discussion

The following summarizes our findings. First, we find a correlation between the timing of the increase in negative media coverage and the decline in trust of UK risk managers. We also find that trust increased significantly corresponding to a decline in the number of negative media, contrary to the trust asymmetry hypothesis.

Second, people who do not trust risk managers of biotechnology are not a homogeneous group. Some of these people are uncertain as to their trust of any source of biotechnology information, some distrust risk managers but appear to be willing to trust other sources of biotechnology information, while others are unwilling to trust any source of biotechnology information. This last group of nontrusters became distinguishable as a distinct category at the peak of the negative biotechnology media events; their numbers are small but increased significantly between 1999 and 2002. Moreover, there is little change in the percent of people who are uncertain (e.g., report “don’t know” when asked about whom to trust with respect to biotechnology issues). Thus, negative media events appear to affect the distribution of people who *already* have an opinion.

Third, of the variables we examine to distinguish among trust, distrust, nontrust, and uncertainty of biotechnology risk managers, knowledge of science is the most important. Knowledge of science is correlated with trust (positively) and uncertainty of trust (negatively), as well as with trust in scientists (positively) for each wave of the *Eurobarometer*, as well as all types of risk managers in 2002 (Table 2). Generalized knowledge is also correlated with trust in risk managers, but its effect is not as pronounced when compared with specific knowledge of science. Generalized knowledge is important at the beginning and end of our analysis horizon, but not at the crucial period of 1999 when negative media events regarding biotechnology were at their peak. In contrast, while correlated with trust, perceptions of benefits and risks take a secondary role to knowledge in distinguishing among categories of trust when controlling for other factors expected to affect trust.

Because the negative media events appear to affect respondents who already have an opinion, and because knowledge of science is the dominant variable for the first discriminant function in each year of the study, scientific knowledge, more than generalized knowledge or perceptions of benefits and risk, might be relevant in moderating the trust asymmetry hypothesis in a way that is consistent with the confirmatory hypothesis. According to Poortinga and Pidgeon (2004), the confirmatory hypothesis is the idea that people respond to information that confirms or reinforces their *prior* beliefs. When negative media events regarding biotechnology occur, reported trust may decline—that is, people who initially trusted biotechnology risk managers may initially begin to distrust risk managers. However, knowledge of science may allow these people to see through the media haze and, in time, discount those reports that do not conform to their understanding of science. People with adequate knowledge of science may recognize if risk managers are being “truthful” or if they are responding to the crisis competently, thus providing a foundation for a renewal of trust.

While knowledge may be important in affecting trust and ultimately public acceptance of biotechnology, one must be cautious in drawing conclusions that the “solution” to problems of a *lack* of public trust in risk managers of biotechnology is simply to increase the scientific knowledge of the public. Knowledge is not a “unidimentional construct” (House et al., 2004) in the sense that it can be easily measured and consequently imparted to the public. The reason, as demonstrated in this study, is that those who do not trust are not a homogeneous group. People who are uncertain about their trust may benefit from an increased knowledge of science so that they can eventually have a basis for forming an opinion about biotechnology. However, distrusters are not the same as nontrusters. Nontrustors, who trust no group or individual regarding biotechnology information, will likely not trust the entities attempting to increase public knowledge of science. Distrustors, on the other hand, may respond to efforts to increase scientific knowledge, but not if it comes through risk managers—that is, industry, universities, or government.

Thus, more research is needed to understand the characteristics of different categories of people who do not trust risk managers of biotechnology. For example, when are people who distrust risk managers distinguishable or non-distinguishable from nontrusters? Is there a significant percent of people who distrust all sources of biotechnology information, and is this group increasing or decreasing in size overtime? Are there cross-country differences in the types of people who do not trust risk? Are factors that improve trust of distrusters the same as those that will be helpful to nontrusters? What about people who are uncertain? Knowledge of science may help here, but is that sufficient? These questions deserve further attention by scholars interested in pursuing an understanding of the nature of public trust of risk managers of biotechnology.

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