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

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Abstract: The mid to late 1990s saw a series of negative media events in the United Kingdom (UK) related to biotechnology. According to the trust asymmetry hypothesis, such events ought to cause public trust in risk managers of biotechnology to fall quickly but rise slowly. We present evidence from the *Eurobarometer* surveys that from 1996 to 1999 public trust in the UK declined, but it increased sharply between 1999 and 2002. We seek to explain this apparent contradiction to the asymmetry hypothesis. We use canonical discriminant analysis of public trust to show that whether people trust or distrust risk managers of biotechnology depends significantly on the amount of knowledge people have about science. We speculate that knowledge of science moderates the trust asymmetry effect.

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Introduction

On March 20, 1996, the British government announced that scientists had discovered a new variant of Creudzfeldt-Jakob disease 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 of 40% (DTZ Pieda Consulting). Some observers argued that the 1996 announcement "shattered any remnants of credibility enjoyed by the British government" (Powell and 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 biotech crops and foods, some have concluded that it did contribute to a general climate of "extreme mistrust" of the UK Ministry of Agriculture, Food and Fisheries (Powell and Leiss, 1997).

Following the 1996 BSE announcement, there were a series of other alleged food and environmental safety events directly linked to biotechnology that were highly reported in the UK media (Marks et al., 2002, 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 Monarch butterflies could be harmed by biotech corn pollen and 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 in the UK media.

We were interested in understanding how these events are correlated with public trust in risk managers in the UK. 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 believed to be a key factor in public perception of complex technologies, such as biotechnology (White and Eiser, 2005; Kasperson et al., 2003; Siegrist and Cvetkovich, 2000). In this context, 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 around the year 1999 (see Marks et al., 2002, 2003), we examined data from the 1996, 1999 and 2002 waves of the *Eurobarometer* (European Commission, 1997, 2000, 2003). We find that the percent of respondents who had confidence (our measure of trust) in risk managers of biotechnology declined from 40.19 percent in 1996 to 34.39 percent in 1999, but it increased to 50.30 percent 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 (see Figure 1). We find this interesting. We expected there to be a decline in public trust from 1996 to 1999 because of the growing negative public and media attention to food and crop biotechnology which peaked in 1999 (Marks et al., 2002, 2003), but the increase in trust in 2002 is unexpected. Negative public events not only should 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). The reason is that trust-destroying events are often more visible than trust-creating events, and they are also usually perceived as being more credible that positive ones (Slovic, 1993; Siegrist and Cvetkovich, 2001).[1]

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[1] Following the approach of Slovic (1993) we label negative public events as "trust-destroying." However, more broadly any event that leads to an erosion of trust might be considered – whether singularly or as an accumulation of

Figure 1 about here

Although the idea of trust asymmetry is recognized in the literature, “there has been relatively little empirical research on trust asymmetry” White and Eiser (2005, p. 1187). What evidence does exist is generally supportive (Slovic, 1993; Poortinga and Pidgeon, 2004; White and Eisier, 2005). However, scholars have also suggested that there might be factors moderating the trust asymmetry hypothesis. For example, White and Eiser (2005) show that two of these factors are how specific reported information is and how hazardous people perceive risks; the less specific the information and the lower the perceived risk to life or health, the less likely people will react negatively to it. Poortinga and Pidgeon (2004) provide evidence of a confirmatory bias, in which people interpret events according to their pre-existing attitudes; people more inclined to accept biotechnology react less negatively toward negative media coverage than those already opposed to the technology.

The purpose of this paper is to provide some insight into the pattern of trust we observe, drawing on data from the 1996, 1999 and 2002 waves of the *Eurobarometer*. To this end we consider the possibility people who do not trust risk managers might not be a homogenous group. That is, some distrustors might still trust other entities or organizations with respect to information or reports about biotechnology. Other people might be unwilling to trust any group or individual. Because we recognize the potential for there to be different categories with respect to trust of risk managers, we use canonical discriminant analysis to identify patters in factors expected to correlate with public trust in risk managers during each of the three waves of the *Eurobarometer* survey. We find that perceptions of risks and benefits are correlated with public

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previous events.

trust. However, we believe the pattern of trust we observed is best explain by a combination of the confirmatory hypothesis and the importance of generalized knowledge of science.

Informational Biotechnology Events

BSE

Bovine spongiform encephalopathy (BSE) or "mad cow" disease was first discovered in the British beef herd in November 1986. By 1988 1,000 cattle had been discovered with BSE, and the UK government made it a reportable disease and instituted a ban on ruminant offal in cattle feed. By August 1988, the government decided to slaughter and incinerate all cows suspected of having BSE and to provide compensation to farmers at 50 percent of the animal's estimated worth (Powell and Leiss, 1997, p.5). The British media began to speculate on a potential unknown risk associated with the consumption of beef from infected cattle. The link between BSE and its potential for a human version of Creudzfeldt-Jakob disease was argued in British newspapers, "the possibility of BSE 'jumping' to human beings is far from absurd" noted the Guardian (Guardian, November 15, 1988, p.38). The government's failure to compensate farmers fully for slaughter of infected cattle was criticized as insufficient -- farmers would fail to report their diseased cattle if full compensation was not paid and infected animals would end up in the food supply. Meanwhile, the government continued to argue that the disease had not affected meat, and could not be passed on to humans by that means. The first serious crisis of confidence in beef came in 1990 when "mad cat disease" was discovered – that is, BSE was found to jump the species barrier to cats. Consumption of beef declined, although it eventually recovered during the early 1990s. Then, in 1995, Granada Television's *World in Action* broadcast a documentary about a nineteen-year-old boy who had died from CJD in May. The government chose not to make any inquiry into the death and continued to argue that there was no evidence that BSE could cause CJD (Powell and Leiss, 1997, p.8). Other potential cases began to be identified through investigative reporting during 1995. On the industry side, slaughterhouse owners were told to tighten their practices as evidence emerged that some carcasses were leaving abattoirs without the offal removed. In late 1995, the scientific debate concerning a link between BSE and CJD was conducted in British academic journals. Yet the British government and industry continued to engage in "no-risk" messages. Finally, British Health Secretary Stephen Dorrell made the announcement in March 1996 that a possible link between BSE and vCJD existed. Powell and Leiss concluded that this announcement was made in a climate of extreme mistrust of the UK MAFF and that it "shattered any remnants of credibility enjoyed by the British government" (1997, p.11).

Bovine Growth Hormone

Bovine Growth Hormone (BGH) or rBST has been approved and marketed in the United States since 1994. First developed by Monsanto, its synthetic version (rBST or recombinant bovine somatotropin) is sold under the brand name Posilac and is a naturally occurring hormone (BST) injected into dairy cattle to increase their supply of milk. Potential benefits of rBGH include an increase in the milk supply and a price reduction for consumers. Studies conducted prior to its commercialization in 1994 had focused on animal health and milk quality, with researchers concluding that supplemental rBST does not increase the amount of BST in milk, that cows respond to natural BST and synthetic rBST in the same way and that rBST does not alter milk composition (Bauman, 1992).

Despite its apparent safety for human consumption, cows treated with rBGH can produce milk with higher levels of insulin-like growth factor 1 (IGF-1). Insulin-like growth factor 1, produced by humans as well as cows, plays a necessary role in many bodily functions. As a result, there continue to be calls for mandatory labeling of dairy products from rBGH-treated cows. And while the United States has given the green light to BGH, the European Union passed down a decision which prohibited its administration and marketing within the EU in December 1999. This decision was not challenged in court resulting in a definitive ban on the use of rBST in the European Union. The ban came into effect on January 1, 2000. The decision was based on animal health and welfare concerns. Specifically, rBST was determined to increase the risk of clinical mastitis, as well as the duration of treatment of mastitis in cattle. It was seen to increase the incidence of foot and leg disorders in cattle, to adversely affect reproduction, as well as to induce severe reactions at the injection site (Brinckman, 2000, p.170). These regulatory decisions and concerns were covered in UK and US media.

Pusztai Affair

On August 10, 1998, Dr. Arpad Pusztai went on the UK *World in Action* program saying that GM potatoes fed to lab rats caused serious harm to their organs and health. The Rowett Research Institute in Scotland subsequently suspended Dr. Pusztai – eventually forcing him to retire ending a 35 year career – and placed a legal ban on him to refrain from talking to the media about his research findings. This ban remained in place for almost four months. In the mean time, leading British experts in plant sciences from universities and publicly funded research institutes criticized Pusztai's findings and public statements, suggesting his work was a "red herring" and should not be used as an excuse to place a moratorium on the development and growth of genetically modified crops. When Dr. Pusztai was allowed to talk to the media he questioned the testing procedures for genetically modified foods noting that only one paper testing the food safety of genetically modified soya was available in a peer-reviewed international journal (Arthur & Connor, February 17 1999). While Dr. Pusztai's study was generally discredited by mainstream scientific societies and his own research institute, it was subsequently published as a Research Letter in *The Lancet* (Ewen and Pusztai, 1999). The event sparked significant UK coverage during late 1998 and 1999 – effectively heightening the debate about the safety of genetically modified foods in the UK.

Monarch Butterfly

In 1999, John Losey and colleagues at Cornell University published a laboratory study in *Nature* which indicated that Monarch butterfly larvae could be harmed by biotech corn pollen. Bt-corn has genes from Bacillus thuringiensis (Bt) spliced into the plant genes. These GM corn hybrids are very effective against the European corn borer, a major corn pest that is destroyed by the plant's toxic tissue. The engineered corn was considered safe for human consumption. However, Monarch caterpillars feed on milkweed leaves which grow close to corn fields. John Losey suggested that the Bt-corn pollen could represent a serious risk to populations of monarchs and other butterflies if the pollen landed on nearby milkweed and was consumed in the wild by the larvae. He did recognize that more data was needed to confirm or refute this laboratory finding. Yet the study's initial findings did indicate a *potential* and previously unanticipated risk. Subsequent field level studies conducted across the United States and Canada did not confirm this risk. Nevertheless, the monarch butterfly event is associated with a strong risk frame in UK media reporting. Moreover, the original study by John Losey and colleagues was published in the prestigious journal *Nature* and was therefore highly newsworthy (Conrad, 1999; Mazur, 1978, 1984, 1989; Singer and Endreny, 1993).

GM Commingling

On May 18 2000, imported conventional canola seeds in the UK were found to contain some biotech seed which had not been approved for commercialization in European markets at the time. United Kingdom farmers unknowingly planted and multiplied them in their fields. The Ministry of Agriculture admitted that large quantities of GM oilseed rape (canola) had been sown by accident on up to 600 farms. More than 22,000 acres of the contaminated seed had been planted and harvested in Britain in the previous year. A further 11,750 acres were planted in the spring of 2000 before the "mistake" was discovered. The UK government's policy was not to allow GM crops to be grown commercially until 2003, when farm-scale trials and other studies were completed. This admission arguably signaled a failure of the regulatory system and government entities to effectively segregate GM crops in the food supply.

Pattern of Negative Media Events in the UK

These episodes highlight the nature of media events that occurred in the UK during the mid to late 1990s. Importantly, these events coincide with an increase in the quantity of media coverage of agbiotech events in UK throughout the 1990s (Marks *et al*, 2002, 2003), which spiked in 1999 but declined and turned relatively more positive post-1999 (see Figures 2 and 3, reproduced from Marks and Kalaitzandonakes, 2001). For instance, Bauer (2002) found that UK reporters were increasingly negative in their reporting of agricultural biotechnology during the late 1990s. Marks *et al*. (2006) also found more negative framing of biotechnology news during the 1990s.

Their study found that frames were largely driven by risk events – negative events gained more media attention. They conclude that the local focus and selective use of information by UK reporters provides strong evidence that UK media actively framed biotechnology coverage during the late 1990s.

Figures 2 and 3 about here

If negative media coverage impacts trust, as Slovic (1999) argues, then according to the asymmetry hypothesis and because such events peaked in 1999, we would expect reported public trust in risk managers of biotechnology to be lower in 1999 than in 1996; that is, we expect increasing distrust of risk managers. We observe this. However, if such effects are asymmetric, in that trust is quick to decline but slow to increase even when there is positive media coverage, we would not expect the observed increase in reported public trust of risk managers between 1999 and 2002 in the UK.

In order to understand our observations on public trust in risk managers, we need to examine more carefully the nature and characteristics of trust. Our purpose is to determine if factors expected to be correlated with trust and distrust provide insights as to why our observations are not fully consistent with the trust asymmetry hypothesis.

Public Trust and Risk Perceptions

Although there are many ways of conceptualizing trust (see Hardin, 2001), at a minimum trust entails an expectation regarding the behavior of others, and that, to be meaningful, trusting behavior must create vulnerability in the person trusting (e.g., Hosmer, 1995; Mayer, Davis

Schoorman, 1995; Nooteboom, 2002; James, 2002a). If, by trusting, we create vulnerability for ourselves, then we ought to have "good grounds" for doing so. According to Baier (1986, p. 235),

> Reasonable trust will require good grounds for such confidence in another's good will, or at least the absence of good grounds for expecting their ill will or indifference. Trust, then, …is accepted vulnerability to another's possible but not expected ill will (or lack of good will) toward one.

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 rooted in the expectation of *trustworthiness* of the person or entity in whom trust is placed (James, 2002a). Slovic (1993, p. 677) offers an insightful reason for the importance of trustworthiness when he noted that trustworthiness requires "a relatively large number of confirming instances to establish the trait and a relatively small number of relevant instances to disconfirm it," because favorable traits are "hard to acquire … and easy to lose," while unfavorable traits are "easier to acquire and harder to lose."

Expectations of trustworthiness reflect two distinct components – perception of the motives and incentives of those in whom trust is placed, and perception of their competence. 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 component of trustworthiness is lacking, then we would not expect there to be trust. Moreover, there is an important distinction between perceptions of honorableness and 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 is honorable 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 honorableness and competence affect trust (James, 2003, 2006). 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, and Chaiken, 1978; Kasperson, 1986; Renn and Levine, 1991; Dholakia and Sternthal, 1997; Peters, Covello, and McCallum, 1997). The *reporting bias* aligns with the notion of perceived honorableness, 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.

Expectations of trustworthiness (honorableness 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 honorableness 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 will likely trust others. However, "likely to trust" 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.

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, that is, through framing of hazard events (Slovic, 1993; Eagly et al, 1978). 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; Burt and Knez, 1996; Dasgupta, 2000; Levi, 1998; Rempel *et al*. 1985). Moreover, Slovic (1993) suggests that once trust begins to fall, 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 and Eiser, 2005, p.1189). People also perceive negative information is more credible than positive information (Siegrist and 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).

We are also interested in understanding why we observe that public trust of risk manager in the UK increased in 2002, as shown in Figure 1 (see also Table 1). What might explain the moderation of the trust asymmetry hypothesis we observe? Perceptions of risk and benefits could play a role. But, as Slovic (1993) and other argue, positive media coverage will not be expected to increase trust as much as media coverage of negative events reduce public trust. Furthermore, we do not have compelling evidence that any positive media coverage that may have occurred after 1999 was equal to or exceeding the apparent negative coverage occurring prior to 1999. Therefore, we seek additional insights as to how and why we might not expect to observe the trust asymmetry effect.

One possibility comes from White and Eiser (2005) who, in addition to finding general support for the trust asymmetry hypothesis, also found that the negative effect on trust was less evident for policy-related events and for events perceived as being low-risk than for concrete events and events considered high-risk. Positive-policy related information can partially counteract the harmful effects of negative event-related information. We do not think these explanations are relevant in this case because the events reported in the media were actual events, not policy related (e.g., commingling of GM and non-GM crops was found, or evidence was reported that GM foods were harmful) and because the harms were potentially serious (e.g., sickness or death from the consumption of adulterated foods). Another possibility is suggested by White, Pahl, Buehner and Haye (2003) and Poortinga and Pidgeon (2004), who proposed the confirmatory bias hypothesis. In their view the prior beliefs and attitudes of people influence how they react to media events. Events consistent with their prior beliefs confirm them while events inconsistent with their prior beliefs are discounted, so that people already generally supportive of biotechnology and trusting of biotechnology risk managers will be less influenced by negative coverage. We believe there is some credence to this hypothesis, although we propose that it works well when understood in conjunction with the generalized knowledge people posses. Because most people do not have a strong understanding of basic science, especially in the context of biotechnology (Durant, Bauer, and Gaskell, 1998; Miller, 1998), people may not have the capacity to interpret correctly media messages regarding risks and benefits of biotechnology (Siegrist and Cvetkovich, 2000). For this reason, people will have an incentive to trust scientists and other experts. Indeed, there is evidence that public trust of scientists is relatively high (Lang and Hallman, 2005; James, 2006). Thus, what is the relationship between knowledge and public trust? According to Siegrist and Cvetkovich (2000), the direction of causality is as follows: If people have little knowledge of science, then they will have an incentive to trust experts (e.g., scientists); if people trust scientists, then they will perceive less risks and more benefits from biotechnologies. This suggests that there should be a negative correlation between knowledge of science and social trust. The problem with this explanation is that it leaves open the question of whether low-knowledge persons are *more* likely to trust scientists than persons with adequate knowledge of science. It could be that people who have 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 trustworthiness or credibility of experts. In this sense social trust might be positively correlated with knowledge. If trust is positively correlated with knowledge, then knowledge might be a moderating factor of the trust asymmetry hypothesis. And, if people with knowledge of science 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 changed over time but also how factors and specific informational events predicted to affect trust change over time. We also consider the possibility that respondents who do not trust risk managers might not be a homogeneous group. Most studies of trust dichotomize trust into *trust* and *no trust* (e.g., James, 2003, 2006). However, we recognize that respondents who do not trust risk managers may trust other entities (e.g., they show distrust toward risk managers), or they may not trust any entity (e.g., they show non-trust). Moreover, people who "don't know" whether they trust risk managers may not be the same as people who simply do not trust anyone (see Faulkenberry and 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) will provide insight into our finding that public trust in risk managers increased after a decline seemingly caused by negative media events, in opposition to what was expected as a result of the trust asymmetry hypothesis.

Analysis

We use data from the 1996, 1999 and 2002 waves of the *Eurobarometer* to examine how trust-eroding events affect trust and factors expected to correlate with trust. We focus on the perceptions of trust of respondents in the United Kingdom only because the BSE, bovine growth hormone, Pusztai affair, Monarch butterfly and GM commingling stories described above were heavily, though certainly not exclusively, reported in the UK. We also know, based on studies by (Marks et al., 2002, 2003) and others, how heavily these stories had been reported in the UK media.

In each wave of the *Eurobarometer,* respondents were asked how much confidence they have in various organizations to "tell the truth about modern biotechnology." The list of organizations includes industry, universities, government,[2] and other non-governmental, political, and special interest organizations. Respondents were then 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: Respondents exhibited *distrust* if they did not indicate any confidence in risk managers but did place confidence in other organizations, such as consumer or environmental interest groups, or religious organizations. Respondents exhibited *nontrust* if their response to which organizations they had confidence in was "none of the above." Finally, respondents were *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 and 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 all variables used in our analysis.

[2] In 1996 the option presented to respondents was "Public authorities." In 1996 and 2002, the term "National government bodies" was used instead.

For explanatory variables we are constrained by the need to use the "same" explanatory variables for each year in order to provide a meaningful comparison across the three years (1996, 1999 and 2002). Unfortunately, the *Eurobarometer* does not always ask the same questions in each wave of the survey. 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 commons 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. Perceptions of risks 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 knowledge of science and trust, we include a variable constructed from the total number of basic science and genetics questions respondents answered correctly (out of 9 possible). 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 percent level or better in difference of means test. The decline in public trust from 1996 to 1999 is expected because, as (Marks et al., 2002, 2003, 2006) state, media attention on negative biotechnology events increased during this time period, peeking in 1999 (see Figures 2 and 3). Although trust in each type of risk manager (industry, universities and governments) declines between 1996 and 1999 (see Figure 1), the change is significant for only government. However, trust increases between 1999 and 2002 for each of these categories, and this increase is significant at the 10 percent level or better. 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 and Hallman, 2005).

Figure 4 reveals how trust changes between 1996 and 2002 relative to distrust, nontrust and uncertainty. First, in 1996 and 1999, distrustors of risk managers are the largest percentage group, followed by trustors. In 2002, however, one-half of all respondents indicate at least some trust in risk managers. Second, those who do not trust risk managers do not appear to be a homogenous group. We observe clear differences among people who distrust risk managers but trust other organizations and entities, people who trust no one, and people who are uncertain. Third, the percent of respondents who express uncertainty with respect to public trust is relatively stable across all three waves of the Eurobarometer. Fourth, in 1999 the increase in the percent of people who distrust risk managers appears to come both from those who trusted risk managers in 1996 and those who trusted no group in 1996. However, after the peek in media coverage in 1999, some distrustors of risk managers became trustors while others became nontrustors. Because the *Eurobarometer* is not a panel study, we can only speculate as to whether the increase in trust in 2002 came from those who had trusted in 1996. Our analysis below lends some credibility to this possibility.

Because people who do not trust risk managers are not a homogenous group, and in order to understand what factors distinguish respondents who trust or distrust risk managers, or who have no trust in any organization or who are uncertain, we conduct 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 discriminate among the four categories of trusting thereby allowing us to predict whether a respondent trusts, distrusts, has no trust or is uncertain. To accomplish this, 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 N-1 times, thereby creating N-1 orthogonal discriminant functions, where N 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 because we cannot, a priori, assign an 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 conduct an ordered Probit 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, say, distinct in a meaningful way relative to 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 can provide insight into this question and, as we explain below, help us understand why our observation of trust in risk managers does not fully conform to the trust asymmetry hypothesis.

Table 2 presents the results of the 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. Examining initially the first discriminant function we find that the explanatory variables explain six percent (in 1996) and nine percent (in 1999 and 2002) of the variability in the first discriminant function. In fact, this function clearly separates each group from the other, and it is statistically significant for each of the three years. Moreover, knowledge of science is clearly the dominant variable for this function, meaning that knowledge of science is the most important variable for discriminating among people who trust risk managers, distrust risk managers but trust others, trust no group or individual (with respect to biotechnology) and those who are uncertain. In the case of the second discriminant function, the explanatory variables explain only about one percent of the variability in the function across each year. This function is statistically significant at the 5 percent level for only years 1996 and 1999. Within this function, perceptions of risks and benefits are most responsible for discriminating among the four trust categories.

Because the first two discriminant functions are statistically significant (except in 2002, in which only the first function is significant), we can conclude there are differences among the four trusting categories. Accordingly, mean values of the group centroids for each function are reported in Table 2 and plots of these means are given in Figure 5. As seen in Figure 5, the first function provides a clear distinction among each of the four trust categories. Because this function is dominated by the variable representing knowledge of science, we can conclude that higher levels of knowledge of basic science corresponds to a movement from uncertainty to nontrust and distrust to trust. Interestingly, the year 1999 appears to be distinct from 1996 and 2002, in that the relative relationship among categories distrust and nontrust reverse.

Within the second discriminant function we observe that there are no differences between those who trust and those who are uncertain, on the one hand, and people who distrust or trust no group, on the other hand. This function is dominated largely by perceptions of risks and benefits. Given the relative signs on the coefficients of these two variables, we can conclude that increases in perceived benefits and decreases in perceived risks result in one less likely to distrust or non-trust.

Table 3 presents correlation coefficients between the perceived benefits, risk and knowledge variables and the trust measures. Importantly, we observe a strong positive correlation between knowledge and trust in risk managers, and a negative correlation between knowledge and respondents having an uncertain response to the question of trust. This pattern holds for each year of the *Eurobarometer* and is contrary to the findings of Siegrist and Cvetkovich (2000). Knowledge of science is also highly and positively correlated with trust in scientists. Expected benefits of biotechnology is correlated with trust and negatively correlated with distrust and uncertainty.

Discussion

The following summarizes our findings. First, generalized knowledge of science seems to be an important factor distinguishing among all four trusting categories. Knowledge is highly correlated with trust (positively) and uncertainty (negatively), as well as with trust in scientists (positively) for each wave of the *Eurobarometer* (see Table 3). Knowledge of science not correlated with distrust or nontrust, which is why along the first discriminant function these two variables hover close to zero on the horizontal scale. Second, people who are uncertain (e.g., report “don’t know” when asked about whom to trust with respect to biotechnology issues) are largely unaffected by media events. Media events affect trustors and distrustors (including people who trust other organizations and people who trust no other organization). They are not affected largely by media events. Third, perceptions of risk and benefits affect trust by making people either more or less likely to distrust risk managers, but knowledge of science dominates the first or dominating discriminant function, such that increases in knowledge leads one to be more likely to trust risk managers.

We find that there appears to be a correlation between the increase in negative media coverage and the decline in trust of risk managers. We also find that trust increased, contrary to the trust asymmetry hypothesis. We believe that part of the reason for this observation rests with the confirmatory hypothesis (see Poortinga and Pidgeon, 2004), which states that people respond to information that confirms or reinforces their prior beliefs, when it is combined with an understanding of the role that knowledge of science has in mitigating the negative effects of negative media information. When people hear or observe negative events of biotechnology, people will likely have some negative reaction (consistent with the negativity bias), for instance, by reducing their trust in risk managers. However, people who have an understanding or knowledge of science will begin to sift through the media messages and, in time, discount those reports that do not conform to their understanding of science. If they come to believe that the reports have little basis in scientific or objective fact, then any distrust the negative media reports created might then return to trust. In this case, generalized knowledge of science can mitigate the negativity bias and, hence, moderate the trust asymmetry effects if people come to realize that negative information regarding biotechnology is not scientifically valid.

While most previous studies have focused on the relationship between acceptance of biotech foods and knowledge (see for example House et al, 2004) and effects of perceived risks and benefits on public trust in risk managers, our study finds a strong correlation between the level of trust placed in risk managers and knowledge about science, including biotechnology. This effect appears to be robust over time. This finding is important as it suggests that educational programs can have some influence over the degree of trust that citizens place in risk managers.

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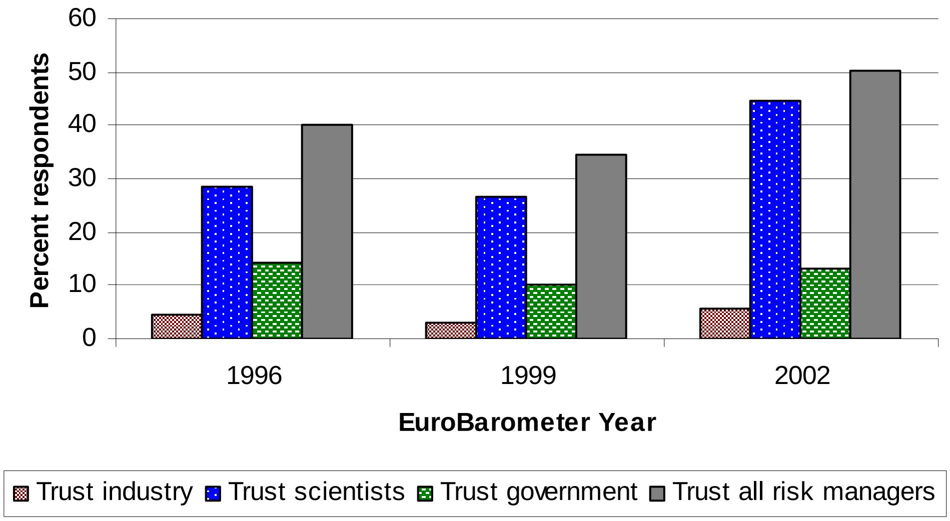
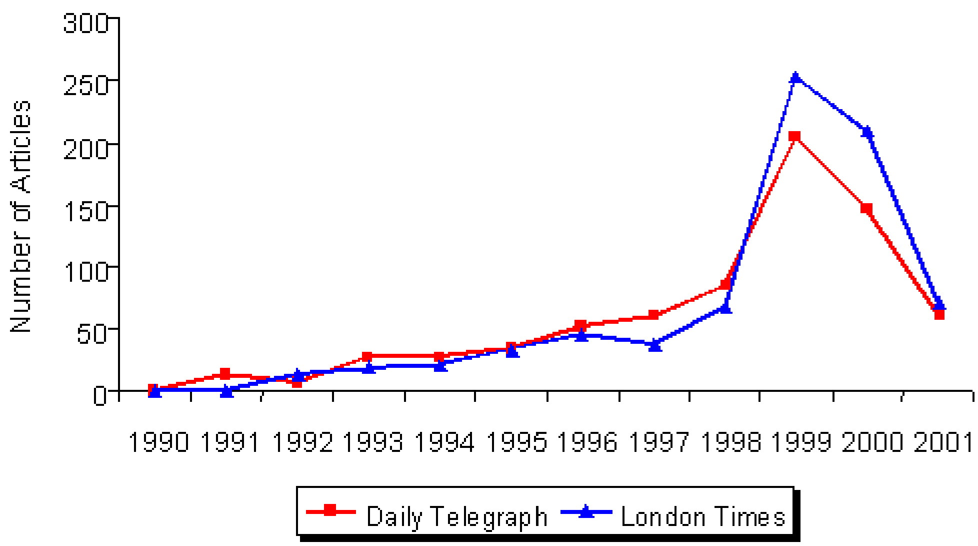
Figure 1: Percent of survey respondents from the UK reporting trust in industry, scientists, government and, collectively as risk managers of biotechnology, in 1996, 1999, and 2002.



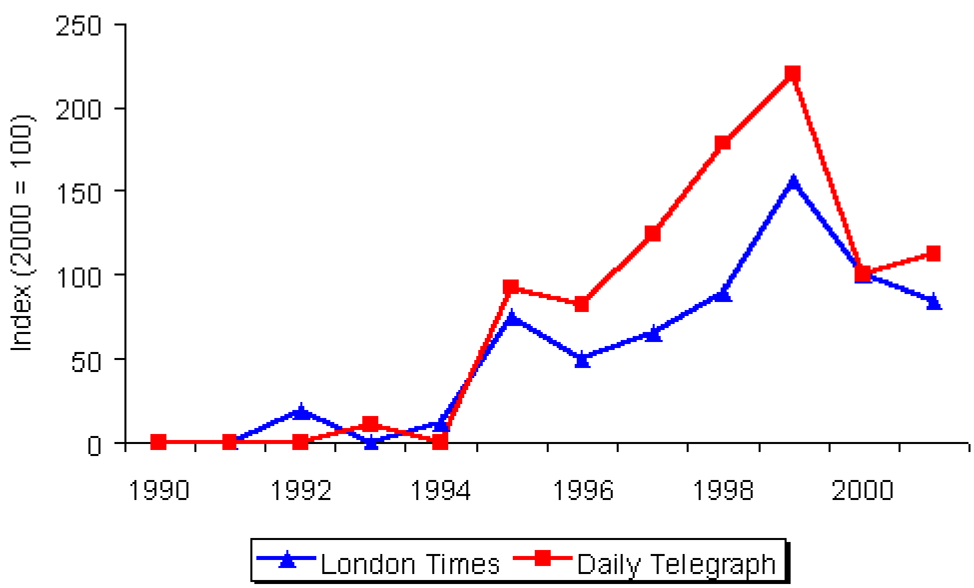
Source: *Eurobarometer*, 1996, 1999, 2002, UK only, authors calculations

Figure 2: Media Coverage of Agbiotech in UK Newspapers, 1990 – 2001



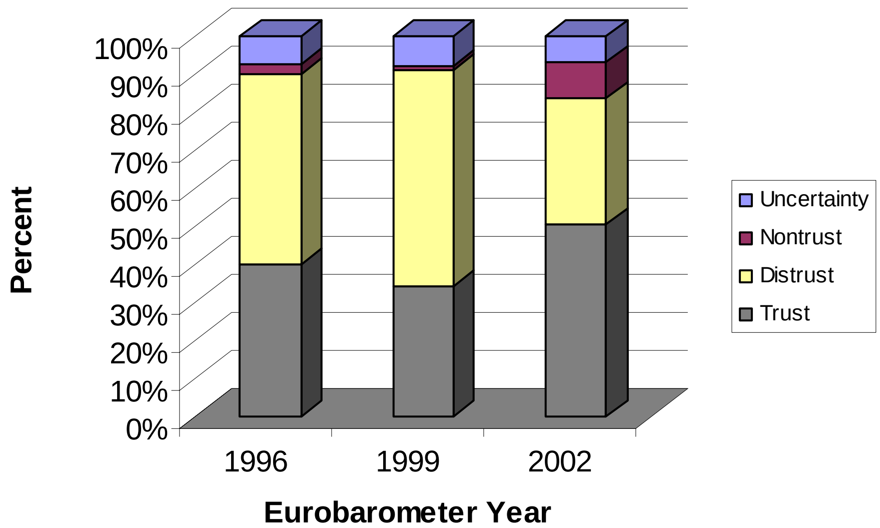
Source: Marks and Kalaitzandonakes (2001).

Figure 3: Linkage of agbiotech coverage with food safety risk events in UK Newspapers, 1990 to 2001



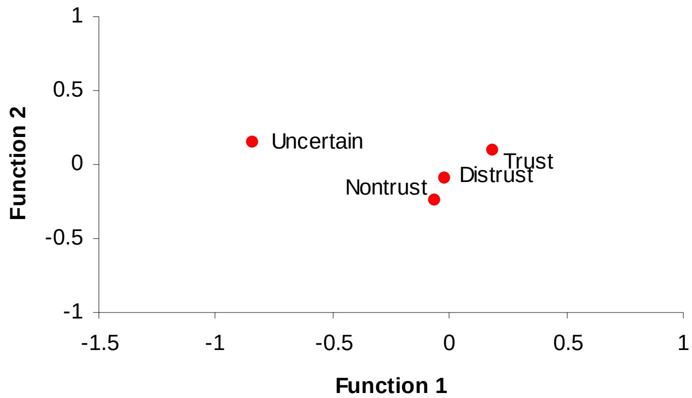
Source: Marks and Kalaitzandonakes (2001).

Figure 4: Percent of survey respondents from UK reporting trust, distrust, nontrust and uncertainty with respect to risk managers of biotechnology, in 1996, 1999, and 2002.

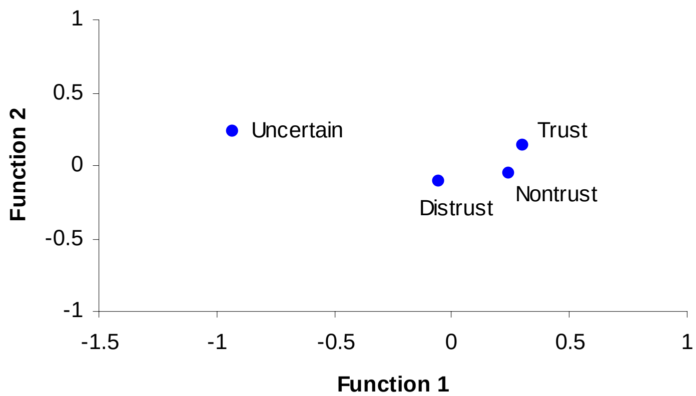


Source: *Eurobarometer*, 1996, 1999, 2002, UK only, authors calculations

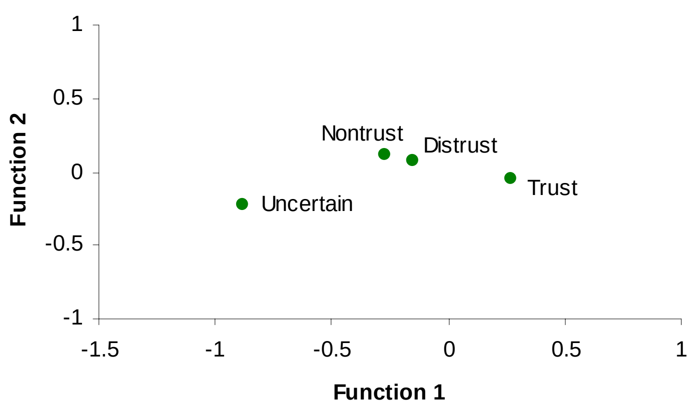
Figure 5. Location of group centroids from discriminant function analysis of trust, distrust, nontrust and uncertainty in the UK, in 1996, 1999 and 2002



(a) *Eurobarometer* year 1996



(b) *Eurobarometer* year 1999



(c) *Eurobarometer* year 2002

Table 1. Summary statistics

	Eurobarometer Year		
	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 from plants to crops is too risky	72.03	56.48	50.30
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 and 2002 years, UK only, authors calculation

Table 2. Standardized canonical discriminant function coefficients.

	1996 *Eurobarometer*		1999 *Eurobarometer*		2002 *Eurobarometer*	
	Function 1	Function 2	Function 1	Function 2	Function 1	Function 2
Will improve life	0.350	0.689	0.230	0.807	0.485	-0.498
Risky	0.211	-0.536	0.212	-0.585	0.156	0.469
Knowledge of science	0.604	-0.302	0.739	-0.191	0.776	0.215
Talked about	0.392	-0.081	0.242	0.157	0.103	0.094
Male	0.230	0.320	0.189	0.097	-0.141	0.068
Age category	-0.057	-0.017	-0.130	0.082	0.007	0.668
Eigenvalue	0.066	0.011	0.103	0.017	0.103	0.008
(prob)	(<.0001)	(0.0436)	(<.0001)	(0.0048)	(<.0001)	(0.3000)
Canonical correlation	0.249	0.104	0.305	0.130	0.305	0.086
Squared canonical corr	0.062	0.011	0.093	0.017	0.093	0.007
Wilke's Lambda	0.925		0.890		0.899	
F stat (d.f.=18)	6.03		8.95		7.93	
(prob)	(<.0001)		(<.0001)		(<.0001)	
Group Centroids						
Trust	0.185	0.099	0.301	0.131	0.268	-0.045
Distrust	-0.023	-0.089	-0.058	-0.111	-0.149	0.077
Nontrust	-0.062	-0.238	0.239	-0.059	-0.271	0.118
Uncertain	-0.840	0.143	-0.932	0.233	-0.884	-0.219

Source: *Eurobarometer*, 1996, 1999 and 2002 years, UK only, authors calculation

Table 3. Correlation coefficients between key explanatory variables and trust variables.

	1996 Eurobarometer			***1999 Eurobarometer***			***2002 Eurobarometer***		
	Improve Life	Risky	Knowledge	Improve Life	Risky	Knowledge	Improve Life	Risky	Knowledge
Trust industry	**0.060**	-0.039	0.032	0.042	**-0.062**	0.022	**0.094**	0.008	**0.054**
Trust scientists	**0.086**	-0.027	**0.118**	**0.146**	0.027	**0.191**	**0.167**	0.046	**0.203**
Trust government	**0.107**	0.014	0.020	**0.105**	-0.032	0.026	**0.124**	-0.014	**0.102**
Trust	**0.123**	-0.015	**0.099**	**0.152**	0.026	**0.176**	**0.177**	0.042	**0.214**
Distrust	**-0.062**	**0.058**	-0.000	**-0.123**	0.044	-0.039	**-0.097**	0.005	**-0.074**
Nontrust	-0.045	0.001	0.010	0.021	0.036	0.013	**-0.054**	-0.002	**-0.073**
Uncertainty	**-0.083**	**-0.083**	**-0.192**	-0.048	**-0.140**	**-0.243**	**-0.107**	**-0.093**	**-0.203**

Bold indicates significant at 5% or better.
Source: *Eurobarometer*, 1996, 1999 and 2002 years, UK only, authors calculation