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

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

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Abstract: During the late 1990s a series of negative events occurred in the United Kingdom (UK) related to biotechnology. These events signaled *potential* risks associated with biotech foods and crops and were highly reported. According to the trust asymmetry hypothesis, such events ought to cause public trust in risk managers of biotechnology to decline rapidly and rebound more slowly. We find, based on data taken from the *Eurobarometer* surveys conducted in 1996, 1999 and 2002, that public trust in risk managers did decline from 1996 to 1999. However, the level of trust rebounded sharply between 1999 and 2002. Canonical discriminant analysis of public trust is used to reveal possible explanatory factors in this response. We find that whether people trust or distrust risk managers depends significantly on the amount of objective knowledge they have. We argue that knowledge of science might moderate 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 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 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 only indirectly related to biotech 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 and 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 that were directly linked to biotechnology and 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 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 (White and Eiser, 2005; Kasperson et al., 2003; Siegrist and Cvetkovich, 2000). We are therefore interested in understanding how these events are correlated with public trust over time. 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 on the late 1990s, we examine data from the 1996, 1999 and 2002 waves of the *Eurobarometer* (European Commission, 1997, 2000, 2003).[1] 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). This finding is important because while a decline in public trust from 1996 to 1999 is predicted, the rebound in trust by 2002 is unexpected. According to the literature, 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 trust-destroying events are often more visible than

[1] Our data naturally brackets the peak in media coverage of *potential* risk events associated with food and crop biotechnologies (Marks et al., 2002, 2003).

trust-creating events, are more highly reported therefore, and they are also usually perceived as being more credible than positive ones (Slovic, 1993; Siegrist and Cvetkovich, 2001).[2]

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 appears to be 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) find that the degree of "informational specificity" and how hazardous people perceive potential risks to be affect the level of trust. The less specific the information and the lower the perceived risk to life or health, the less likely people will react negatively to risk information. 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 information than those already opposed to the technology.

The purpose of this paper is to provide some insight into the pattern of trust observed in the 1996 to 2002 waves of the *Eurobarometer*. To this end we consider the possibility that respondents' degree of trust in risk managers might vary by group. Some distrustors might still trust other entities or organizations with respect to information or reports about biotechnology. Other respondents might be unwilling to trust any group or individual. Because we recognize the potential for there to be different categories with respect to trust, we use canonical discriminant

[2] 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 previous events.

analysis to identify patterns 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 trust. However, we conclude that the observed rebound in trust is best explained by a combination of the confirmatory hypothesis and the importance of knowledge of science.

**Informational Events**

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 infected 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" (Slovic, 2001) associated with the consumption of beef from infected cattle. The link between BSE and its potential for a human version of Creudzfeldt-Jakob disease (vCJD) was argued by British newspapers as early as 1988, "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 also criticized as insufficient -- farmers would fail to report their diseased cattle if full compensation was not paid and infected animals might 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 have jumped 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 (new variant CJD) existed. Powell and Leiss conclude 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) 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 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 did not increase the amount of BST in milk, that cows responded to natural BST and synthetic rBST in the same way, and that rBST did 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 have continued to be calls for mandatory labeling of dairy products from rBGH-treated cows in the United States. And while the United States gave the green light to BGH in 1994, the European reception was more negative. In 1999, the European Union passed down a decision which prohibited its administration and marketing in the EU. This decision was not challenged in court resulting in a definitive ban on the use of rBST from January 1, 2000 onwards. The decision was based on animal health and welfare rather than human health 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 stating that GM potatoes fed to laboratory rats caused serious harm to their organs and health. His comments garnered significant media attention and were controversial. The Rowett Research Institute in

Scotland subsequently suspended Dr. Pusztai – eventually forcing him to retire ending a 35 year career – and placed a 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 plant scientists from British 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 further 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 published as a Research Letter in *The Lancet* (Ewen and Pusztai, 1999). The event sparked significant UK debate during late 1998 and 1999 – effectively heightening coverage of and questioning the safety of genetically modified foods (Marks et al., 2002, 2003).

*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 biotech 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 is considered safe for human consumption. However, Monarch caterpillars feed on milkweed leaves which grow close to corn fields. John Losey and colleagues' research 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. The researchers recognized that more data were needed to confirm or refute this laboratory finding. However, importantly the study's initial findings signaled a *potential* and previously unanticipated risk associated with biotech crops. As a result, the monarch butterfly event was highly reported and associated with a strong risk frame in UK media (Marks et al. 2006). Moreover, the original study by John Losey and colleagues was published in the prestigious journal *Nature*, further adding to its newsworthiness and lending credibility to the study's findings (Conrad, 1999; Mazur and Conant, 1978; Mazur, 1984, 1989; Singer and Endreny, 1993). Subsequent field studies conducted across the United States and Canada did not confirm the original study's findings.

*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, Food and Fiber admitted that large quantities of biotech oilseed rape (canola) had been accidentally sown on up to 600 farms. More than 22,000 acres of the commingled 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 (Brown, 2000). This failure can be contrasted with the UK government's stated policy which was not to allow biotech crops to be grown commercially until 2003, when farm-scale trials and other studies of environmental safety were to be completed. This admission arguably signaled a failure of government and industry entities to effectively segregate biotech 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, which peaked in 1999 (see Figures 2 and 3, reproduced from Marks and Kalaitzandonakes, 2001). Negative framing of agbiotech news also peaked during 1999 with coverage turning more positive post-1999 (Marks *et al*, 2002, 2003, 2006). 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.

Figures 2 and 3 about here

If negative media coverage impacts trust, as Slovic (1999) predicts, 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. 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 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 notes 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.

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, 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 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 and Eiser, 2005, p.1189). People also perceive negative information as 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). 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 comes from White and Eiser (2005) who, in addition to finding general support for the trust asymmetry hypothesis, also found that the negative effect of information on trust was moderated for policy-related events and for events perceived as being lower-risk than for more concrete events and events considered high-risk. They conclude that positive-policy related information can partially counteract the effects of negative event-related information. This explanation is relevant to the UK case because while the events highly reported in the media were concrete, (e.g., commingling of biotech and non-biotech crops was found) they signaled *potential* rather than *actual* realized harms. The potential harms highlighted in media coverage of biotech foods and crops can be contrasted with the actual deaths that have resulted from vCJD.[3]

Another plausible 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 generally supportive of biotechnology and trusting of biotechnology risk managers will be less influenced by negative coverage. However, the knowledge that people possess can also influence information processing. Because lay publics do not always 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 capability to interpret correctly media messages regarding risks and benefits of biotechnology (Siegrist and Cvetkovich, 2000). In this case, 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). Hence, 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, especially if

[3] Of course, hindsight is always 20-20. Nevertheless, ten years post-marketing have revealed no significant health or environmental risks associated with biotech foods and crops.

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 social trust.

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 trustworthiness or credibility of experts. In this sense social 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 represent it as having increased or decreased (e.g., Slovic, 1993; White and Eiser, 2005; Poortinga and Pidgeon, 2004). However, we recognize that respondents who have little or no trust in 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) provide insights 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."[4] The list of organizations includes industry, universities, government,[5] 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: Respondents exhibited *distrust* if they did not indicate any

[4] 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.
[5] In 1996 the option presented to respondents was "public authorities." In 1996 and 2002, the term "national government bodies" was used instead.

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.

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 time. 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. 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 they completed their fulltime education, the greater is their generalized knowledge.[6] We also assume that the more science and genetics questions a respondent answers correctly, the greater is their knowledge of science.[7] 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 as 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 government only. However, trust increases between 1999 and 2002 for each of these categories, albeit weakly, (*p*-value of 0.10 or lower). 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, between 1996 and 1999, distrustors of risk managers are the largest

[6] The variable consists of three categories, coded as 1 if the respondent completed fulltime education at ages 0 through 15, coded as 2 if between 16 and 19, and coded as 3 if education was completed at age 20 or later or still pursuing an education.

[7] 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).

percentage group, followed by trustors. By 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 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 conduct 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, 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 understand why our observation of trust in risk managers does not fully conform to the trust asymmetry hypothesis.

Table 2 presents correlation coefficients between the perceived benefits, risk, generalized knowledge and knowledge of science variables and the trust measures. Importantly, we observe a positive correlation between both knowledge variables and trust in risk managers, and a negative correlation between the knowledge variables 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), who suggested a negative correlation between knowledge and trust. Both knowledge questions are also highly and positively correlated with trust in scientists. Expected benefits of biotechnology is correlated with trust and negatively correlated with distrust and uncertainty.

Table 3 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 squared canonical correlation we find that the explanatory variables explain seven percent (in 1996) and ten percent (in 1999 and 2002) of the variability in the first discriminant function.[8] In fact, the fist function clearly separates each group from the other, and it is statistically significant for each of the three years. Moreover, knowledge of science is the dominant variable for this function, meaning that knowledge of science is the most important variable for discriminating among all four groups. Generalized knowledge, measured by the age (category) at which respondent ended fulltime education, is important in 1996 and 2002 but not in 1999. In the case of the second discriminant function, the explanatory variables explain one to two percent of the variability in the function across each year. This function is statistically significant at the 10 percent level for 1996 and at the one percent level in 1999. Within this function, perceptions of risks and benefits are most responsible for discriminating among the four trust categories for years 1996 and 1999, while in 2002 the most important factors are perceived risks and generalized knowledge.

Based on this analysis, 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 presented in Figure 5. As seen in Figure 5, the first function provides a clear distinction among the trust categories. Because this function is dominated by the variable representing knowledge of science, the positive coefficient on that variable implies that

[8] Although this explains a small percentage of the variation in the dependent variable, overall F-statistics are highly significant.

higher levels of basic science knowledge correspond to a movement from uncertainty to nontrust and distrust to trust. In other words, respondents with relatively high levels of knowledge of science respondents are more likely to trust risk managers than express distrust, nontrust or uncertainty. Respondents with very little knowledge of science are more likely to express uncertainty when asked about how confident they are in risk managers. Respondents with moderate knowledge of science either distrust risk managers or express no trust in any organization. Interestingly, the effect of the first function on distrust and nontrust, which is dominated by the knowledge of science variable, changes over time. In 1996 there is no significant difference between the categories of distrust and nontrust. In 1999 these categories become distinct along the first discriminant function, while in 2002 the distinctness remains but the relative position reverses.

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. Given the relative signs on the coefficients of these two variables, one can conclude that increases in perceived benefits and decreases in perceived risks result in respondents who are less likely to distrust or non-trust.

**Discussion**

The following summarizes our findings. First, knowledge of science seems to be an important mediating factor in the level of trust individuals place in risk managers. Knowledge of science is correlated with trust (positively) and uncertainty (negatively), as well as with trust in scientists (positively) for each wave of the *Eurobarometer* (see Table 3). Second, generalized knowledge is important at the beginning and end of the analysis horizon, but not at the crucial period of 1999 when negative media events regarding biotechnology were at their peak. Third, there is little change in the category representing people who are uncertain (e.g., report “don’t know” when asked about whom to trust with respect to biotechnology issues). On the other hand, categories comprising people who already have an opinion – whether they distrust or trust – change positions over time, suggesting that they might be affected 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 discriminant function, such that increased knowledge leads one to be more likely to trust risk managers.

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, 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 generally, and in particular knowledge of science, have in mitigating the effects of negative media information. We postulate that when people hear or observe negative events, 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 adequate knowledge of science will begin to sift through the media messages and, in time, may discount those reports that do not conform to their understanding of science. Generalized knowledge is not enough here. The important factor seems to be knowledge of (genetic) science, at least in the context of trust of biotechnology risk managers. Moreover, if the *potential* risks identified in media reports are not confirmed by further evidence (of harm) and through experience, as in the case of biotech foods and crops, these individuals might come to believe that the reports have less basis in fact. Hence, the initial distrust created by negative media reports might be mitigated. In this case, knowledge of science seems to mitigate the negativity bias and, hence, moderate the trust asymmetry effects postulated by Slovic and others.

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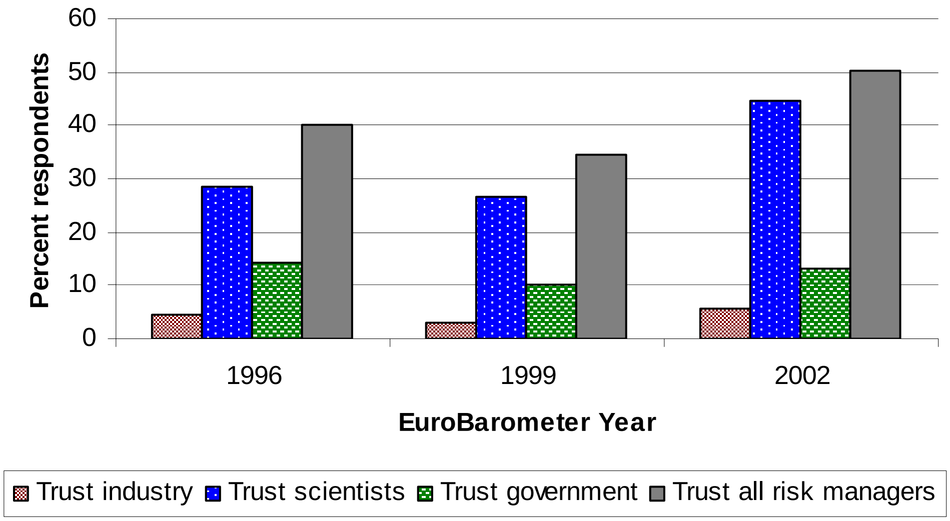
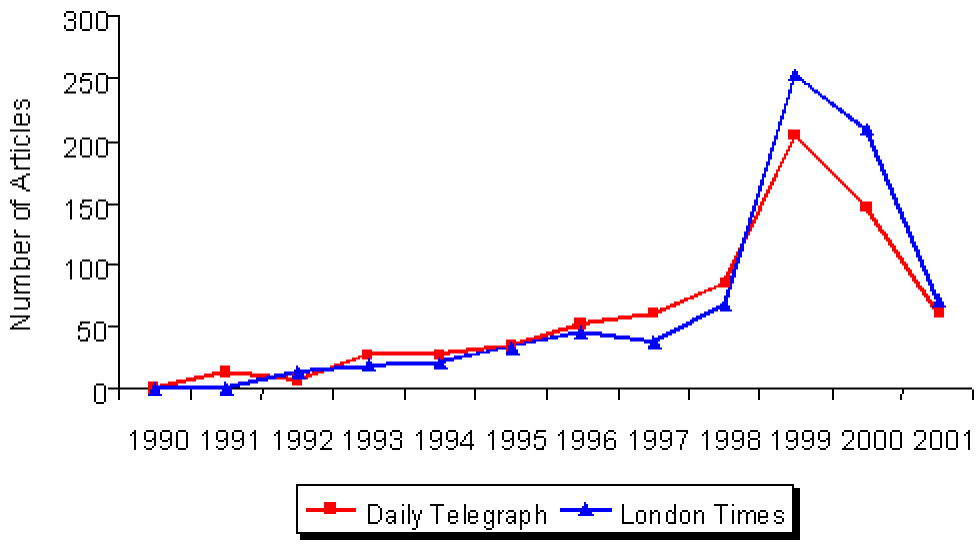
**Figure 1: Percent of survey respondents from the UK reporting trust in industry, scientists, government and, collectively as risk managers of biotechnology, in 1996, 1999, and 2002.**



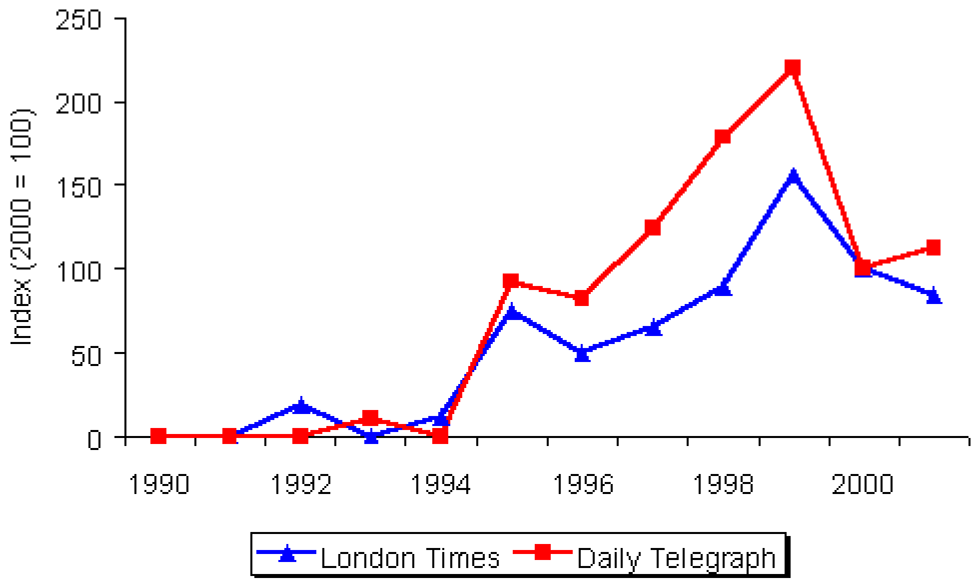

Source: *Eurobarometer*, 1996, 1999, 2002, UK only, authors calculations

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



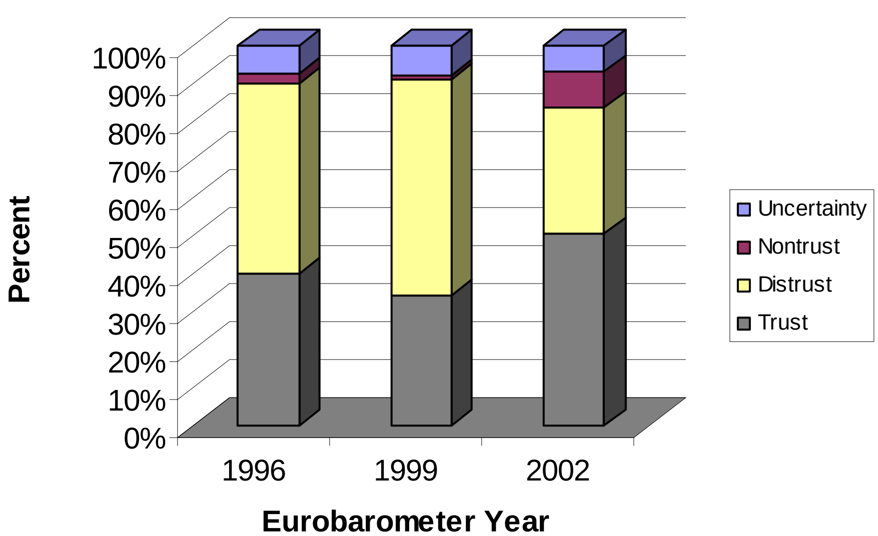

Source: Marks and Kalaitzandonakes (2001).

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



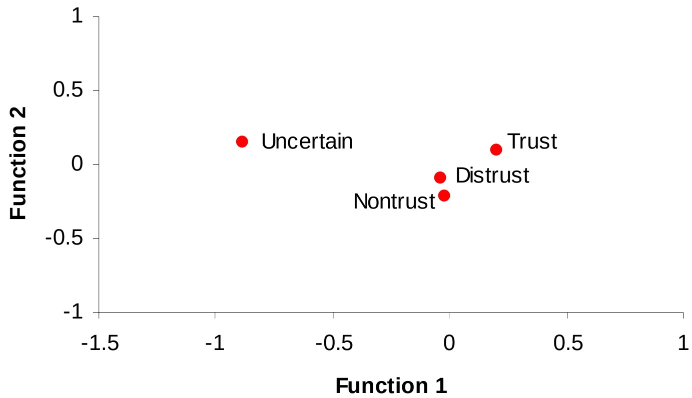

Source: Marks and Kalaitzandonakes (2001).

**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.**

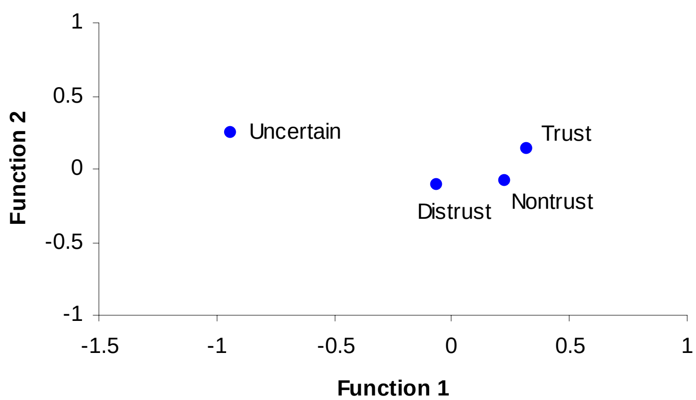



Source: *Eurobarometer*, 1996, 1999, 2002, UK only, authors calculations

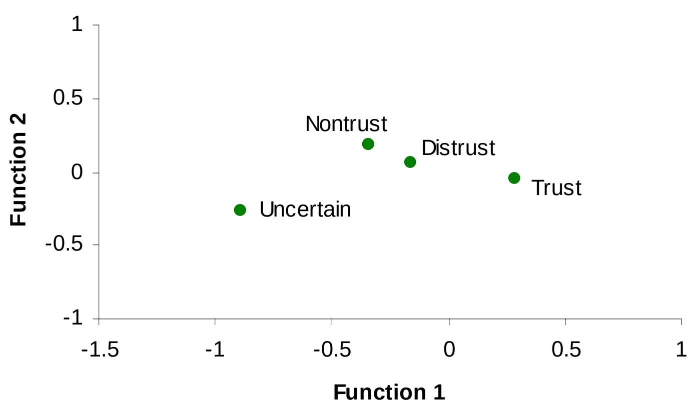
**Figure 5. Location of group centroids from discriminant function analysis of trust, distrust, nontrust and uncertainty in the UK, in 1996, 1999 and 2002**




(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 3 age categories of when respondent finished fulltime education, where 0-15=1, 16-19=2, and 20 and older=3. | 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 and 2002 years, UK only, authors' calculation

**Table 2. Correlation coefficients between key explanatory variables and trust variables.**

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

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

**Table 3. Standardized canonical discriminant function coefficients and group centroids.**

| | **1996 *Eurobarometer*** | | **1999 *Eurobarometer*** | | **2002 *Eurobarometer*** | |
|---|---|---|---|---|---|---|
| | Function 1 | Function 2 | Function 1 | Function 2 | Function 1 | Function 2 |
| Will improve life | 0.315 | 0.662 | 0.225 | 0.763 | 0.431 | -0.247 |
| Risky | 0.181 | -0.552 | 0.197 | -0.588 | 0.132 | 0.433 |
| Age ending education | 0.402 | 0.108 | 0.248 | 0.271 | 0.415 | -0.622 |
| Knowledge of science | 0.501 | -0.337 | 0.692 | -0.258 | 0.681 | 0.371 |
| Talked about | 0.279 | -0.117 | 0.199 | 0.095 | 0.033 | 0.221 |
| Male | 0.230 | 0.315 | 0.193 | 0.093 | -0.115 | 0.051 |
| Age category | 0.098 | 0.038 | -0.014 | 0.215 | 0.203 | 0.277 |
| Eigenvalue | 0.074 | 0.011 | 0.107 | 0.018 | 0.116 | 0.010 |
| (prob) | (<.0001) | (0.0699) | (<.0001) | (0.0089) | (<.0001) | (0.1818) |
| Canonical correlation | 0.263 | 0.104 | 0.311 | 0.134 | 0.322 | 0.101 |
| Squared canonical corr | 0.069 | 0.011 | 0.097 | 0.018 | 0.104 | 0.010 |
| Wilke's Lambda | 0.917 | | 0.886 | | 0.885 | |
| F stat (d.f.=21) | 5.74 | | 7.95 | | 7.75 | |
| (prob) | (<.0001) | | (<.0001) | | (<.0001) | |
| **Group Centroids** | | | | | | |
| Trust | 0.203 | 0.099 | 0.316 | 0.132 | 0.291 | -0.043 |
| Distrust | -0.033 | -0.091 | -0.066 | -0.113 | -0.163 | 0.065 |
| Nontrust | -0.018 | -0.218 | 0.23 | -0.076 | -0.342 | 0.181 |
| Uncertain | -0.882 | 0.149 | -0.939 | 0.248 | -0.888 | -0.266 |

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