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Trust in Scientists and Food Manufacturers: Implications for the Public Support of Biotechnology

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An analysis of data from the U.S. Biotechnology Study, 1997–1998 reveals that few variables affect public trust in scientists, while variables representing perceived benefits, risks, trustworthiness, and competence affect trust in food manufacturers on matters of biotechnology. Both trust in scientists and trust in food manufacturers have a large and important effect on public support for biotechnology, although trust in scientists is found to be more important than trust in food manufacturers. Findings of this analysis suggest that trust in scientists is relatively generalized, while trust in food manufacturers is particularized.

Key Words: biotechnology, genetic modification, public support of biotechnology, public trust, trust

We might expect a relationship between the trust people place in biotechnology institutions and the support they are willing to give to biotechnology research and commercialization. For example, many scholars believe low public support for biotechnology is a sign of a lack of public trust (Brom, 2000; Hampel, Pfenning, and Peters, 2000). One reason offered is that consumers perceive that biotechnology institutions have 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, 1977; Peters, Covello, and McCallum, 1997). These biases are a reflection of the public's perceptions of trustworthiness (e.g., reporting bias) and competence (e.g., knowledge bias), which are recognized within the literature as necessary for trust formation (Hardin, 2004).

The empirical evidence linking trust to public support for biotechnology and genetic engineering, however, is mixed. For example, experiments by Frewer and Shepherd (1994) and Finlay et al. (1999) found little, if any, effect of trust on public

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support, while survey research by Rosati and Saba (2000), Siegrist (2000), and Priest, Bonfadelli, and Rusanen (2003) showed a positive but weak effect of trust on public support. As recently argued by James (2003), based on evidence from the U.S. Biotechnology Study, the low measured effect of trust on public support is explained by the fact that trust is endogenously determined with public support. When this endogeneity is controlled for, public trust of biotechnology institutions is shown to have a large effect on public support for the genetic modification of crop plants and the application of biotechnology in food production.

This paper extends James' (2003) study by modeling separately trust in scientists developing the technology and trust in agribusinesses commercializing it, and by showing how trust in these particular institutions affects the general support by the public for biotechnology. The results show that trust in scientists is higher than trust in food manufacturers, and few variables affect public trust in scientists. In contrast, variables representing perceived benefits, risks, trustworthiness, and competence affect trust in food manufacturers on matters of biotechnology. Furthermore, both trust in scientists and trust in food manufacturers have large effects on public support for biotechnology, although trust in scientists is found to be relatively more important than trust in food manufacturers. These findings suggest that trust in scientists is generalized, while trust in food manufacturers is particularized. As explained below, these differences in trust in scientists and food manufacturers will have important implications for the support the public gives, or does not give, to biotechnology research and applications.

Trust in Biotechnology Institutions

Trust is defined as "the willingness of a party to be vulnerable to the actions of another party based on the expectation that the other will perform a particular action important to the trustor" (Mayer, Davis, and Schoorman, 1995, p. 712). According to this definition, *willingness*, *vulnerability*, and *expectations* are key aspects of trust and trust formation. Willingness reflects confidence that correctly trusting will result in benefits for the truster. Vulnerability reflects the perception that losses can arise when trust is misplaced—i.e., when trust is placed in someone who might (willingly or unwillingly) exploit that trust. Expectations entail a belief in the trustworthiness and competence of the person or entity in whom trust is placed, both of which are necessary for trust. For instance, Hardin (2004, p. 8) states, "Trust depends on two quite different dimensions: the motivation of the potentially trusted person to attend to the truster's interests and his or her competence to do so."

James (2002) developed a model linking willingness, vulnerability, and expectations to trust. In his model, individuals trust when the expected benefits from correctly trusting exceed the expected losses from mistrusting. The expected benefits exceed expected losses as the losses from mistrusting decrease, the gains from correctly trusting increase, and the expectation that trust will not be exploited increases. The expectation of being exploited is assumed to be a function of the trustworthiness and competence of the person or institution in which trust is placed.

Although previous research has linked these factors to trust (e.g., Hunt and Frewer, 2001; Peters, Covello, and McCallum, 1997; Kasperson, Golding, and Tuler, 1992), this paper uses a national survey of U.S. households to examine how perceived benefits, costs, and expectations of trustworthiness and competence affect trust in specific biotechnology institutions—namely, scientists and agribusiness food manufacturers.

Public trust of biotechnology institutions can be modeled by the following binary dependent variable equation:

$$T_i = \boldsymbol{\gamma}'\mathbf{Z}_i + \varepsilon_i, \tag{1}$$

where $T_i = 1$ if we observe trust, and $T_i = 0$ if we observe no trust; $\mathbf{Z}_i$ represents characteristics of individual i; $\boldsymbol{\gamma}$ is a vector of parameters; and ε_i represents unknown characteristics affecting trust. We observe trust when the expected benefits of correctly trusting exceed the expected costs of mistrusting, which is a function of perceived benefits from correctly trusting, perceived losses from mistrusting, and expectations of trustworthiness and competence. Therefore, the set of explanatory variables, $\mathbf{Z}_i$, should include elements representing individual i's assessments of the potential benefits and costs of biotechnology, the trustworthiness and competence of biotechnology institutions, and other control factors. The probability that individual i will trust biotechnology institutions is expected to increase as the perceived benefits from biotechnology increase, the risks or costs of using biotechnology decrease, and the likelihood increases that trust will not be exploited through untrustworthiness or incompetence, other things being equal.

Public Support for Biotechnology and Trust

Earlier studies have identified a number of factors affecting public support for biotechnology, such as perceived risks and benefits, uncertainty, the level of understanding of biotechnology, and moral beliefs about biotechnology. Although public trust of biotechnology institutions has been recognized as a factor, some scholars have argued it is not an important factor (Rosati and Saba, 2000; Siegrist, 2000).

James (2003) points out that previous empirical studies have failed to account for the endogeneity of trust in models of public support, thus explaining why trust is often not found to be important. In other words, suppose we model the effect of trust and other factors on public support for biotechnology by:

$$S_i = \boldsymbol{\beta}'\mathbf{X}_i + \delta T_i + u_i, \tag{2}$$

where S_i is a measure of public support, $\boldsymbol{\beta}$ is a vector of parameters, $\mathbf{X}_i$ is a vector of explanatory variables other than trust, T_i is a dummy variable equal to one if the individual trusts biotechnology institutions and zero otherwise, δ is a coefficient measuring the effect of trust on public support, u_i is an error term, and i is an index for individuals where $i = 1, \ldots, N$.

If T_i in equation (2) is modeled by equation (1), the error terms ε_i and u_i will be correlated. The implication is that trust must be treated as an endogenous rather than exogenous variable in equation (2); otherwise, an estimation of δ will be biased. According to James (2003), one way of correcting for the endogeneity of trust is to replace T_i in equation (2) with an instrumental variable expected to be correlated with S_i but not correlated with the error term u_i. This is accomplished as follows: Equation (1) is estimated with a probit analysis; then the predicted probabilities of T_i, denoted as $\hat{T}_i$, are inserted into equation (2) in place of T_i, resulting in the following corrected version of equation (2):

$$S_i = \boldsymbol{\beta}'\mathbf{X}_i + \delta \hat{T}_i + \mu_i . \qquad (3)$$

Equation (3) now provides a means of examining the unbiased effect of trust on public support for biotechnology. Although James (2003) found that trust in biotechnology institutions has a positive and large effect on public support for biotechnology, he did not distinguish between trust in different types of biotechnology institutions. Accordingly, this analysis extends James' earlier work by examining the effects of trust in scientists and trust in food manufacturers separately on public support for biotechnology.

Methods

Data for this study come from the "United States Biotechnology Study, 1997–1998."[1] This data set was created from telephone interviews of a representative sample of 1,067 U.S. citizens, 18 years of age and older, between November 1997 and February 1998 (Miller, 2000).[2] Respondents were asked questions regarding their attitudes toward biotechnology, their knowledge of science, and other questions related to technology and politics. In this sample, 58.7% of respondents had at least some post-high school education, 49.8% of respondents were male, and the average respondent was approximately 45 years old. Because the data for this study come from a preexisting, publicly available data set, variable and proxy selection are limited by the type and quality of questions utilized in the survey. Table 1 presents a description of all variables used in this study.

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[1] Although the data set used here is relatively dated, there is still value in using it to examine the empirical relationship between public trust and public support for biotechnology. Such a study can help identify variables correlated with trust and support. It can also be used as a basis for assessing changes in factors affecting trust and support, and the trust-support relationship, over time. This is important because relatively few studies exist with U.S. data on the question of how public trust is related to public support for biotechnology.

[2] The data set is publicly available online to member institutions affiliated with the Inter-university Consortium for Political and Social Research at the University of Michigan (at http://www.icpsr.umich.edu/). The data set was made available to the public in November 2000.

Table 1. Definitions, Sample Means, and Standard Deviations of Dependent and Independent Variables (N = 1,067)

Variable	Definition	Mean (Std. Dev.)
Dependent Variables:		
Trust Scientists	Dichotomous variable, =1 if respondent placed a lot or some trust in a statement by university scientists about biotechnology	0.9035 (0.2955)
Trust Food Manufacturers	Dichotomous variable, =1 if respondent placed a lot or some trust in a statement by food manufacturers about biotechnology	0.5511 (0.4976)
Support Biotechnology	Dichotomous variable, =1 if respondent expressed support (rather than opposition) to biotechnology in agriculture and food production	0.7516 (0.4323)
Variables in Trust Model:		
Will Improve Life	Dummy variable, =1 if respondent believes biotechnology or genetic engineering will improve our way of life	0.5989 (0.4904)
Will Reduce Environmental Pollution	Dummy variable, =1 if respondent believes biotechnology will likely reduce environmental pollution within the next 20 years	0.6073 (0.4886)
Will Reduce World Hunger	Dummy variable, =1 if respondent believes biotechnology will likely reduce world hunger	0.4827 (0.4999)
Too Risky	Dummy variable, =1 if respondent definitely agreed or tended to agree that each of the following are risky for society: (1) use of biotechnology in food and drink, (2) inserting genes from plants to crops, and (3) introducing human genes into animals	0.2371 (0.4255)
Likely to Result in New Diseases	Dummy variable, =1 if respondent believes biotechnology will likely result in new diseases within the next 20 years	0.6514 (0.4768)
Likely to Reduce Range of Foods	Dummy variable, =1 if respondent believes biotechnology will likely reduce the range of fruits and vegetables we can get	0.4114 (0.4923)
Current Regulations Sufficient	Dummy variable, =1 if respondent strongly agrees or agrees that current regulations are sufficient to protect people from risks of biotechnology	0.3702 (0.4831)
Industry Can Self-Regulate	Dummy variable, =1 if respondent strongly agrees or agrees that the biotechnology industry can regulate itself	0.1921 (0.3942)
Too Complex for Policy	Dummy variable, =1 if respondent strongly agrees or agrees that biotechnology is too complicated to be sufficiently regulated	0.1715 (0.3771)
Not Worth Labeling	Dummy variable, =1 if respondent strongly agrees or agrees that it is not worth putting labels on genetically modified foods	0.1603 (0.3670)
Variables in Support Model:		
Religious	Scale variable ranging from 0 to 10, based on respondent assessment of how religious he/she is: 0 = not at all religious; 10 = very religious	6.3330 (2.7709)
Biotechnology Is Important	Scale variable ranging from 0 to 10, based on respondent assessment of how important biotechnology is to oneself: 0 = not at all important; 10 = extremely important	7.2110 (2.0132)
Informed About Biotechnology	Scale variable ranging from 0 to 10, based on respondent assessment of how informed he/she is about biotechnology: 0 = not at all informed; 10 = very well informed	4.6792 (1.9765)

(continued . . .)

Table 1. Continued

Variable	Definition	Mean (Std. Dev.)
Variables in Support Model (cont'd.):		
Negative Feelings About Biotechnology	Dummy variable, =1 if the respondent has strongly negative or negative feelings about modern biotechnology	0.1425 (0.3497)
Knowledge of Basic Genetic Science	Number of True/False science questions answered correctly (of a total of 8 questions): (1) DNA regulates inherited characteristics in all plants, animals, and humans. [True] (2) Given today's biotechnology, scientists can now create new genes that never existed in nature. [False] (3) More than half of human genes are identical to those with chimpanzees. [True] (4) The cloning of living things produces exactly identical offspring. [True] (5) Ordinary tomatoes do not contain genes, while genetically modified tomatoes do. [False] (6) By eating a genetically modified fruit, a person's genes could also become modified. [False] (7) It is impossible to transfer animal genes into plants. [False] (8) Genetically modified animals are always bigger than ordinary ones. [False]	4.1940 (1.8873)
Control Variables for Trust and Support Models:		
College	Dummy variable, =1 if the respondent has some college education	0.5867 (0.4927)
Male	Dummy variable, =1 if the respondent is male	0.4977 (0.5002)
Age	Respondent's age (years)	44.7 (15.6)

Note: Based on data set provided through "United States Biotechnology Study, 1997–1998" (Miller, 2000).

The Trust Model

Equation (1) describes the relationship between trust and factors expected to affect trust. Trust in scientists is proxied by a dichotomous variable (*Trust Scientists*) equal to one if respondents placed a lot or some trust in a statement by university scientists about biotechnology. Similarly, *Trust Food Manufacturers* is a dichotomous variable equal to one if respondents placed a lot or some trust in a statement about biotechnology by food manufacturers. As shown in table 1, 90% of respondents reported at least some trust in university scientists, while 55% of respondents placed at least some trust in food manufacturers. Moreover, the standard deviation of trust in scientists is smaller than the standard deviation of trust in food manufacturers, even after controlling for the variable means.

In order to examine factors reflecting perceived benefits, costs, and expectations of trustworthiness and competence on trust, a probit model is estimated in which trust in scientists and trust in food manufacturers are treated as dependent variables.

Perceptions of benefits of biotechnology are proxied by variables representing respondent beliefs about whether biotechnology will improve our way of life, whether biotechnology will likely reduce environmental pollution, and whether biotechnology will reduce world hunger. In each case, an increase in the variable is expected to have a positive impact on trust in both scientists and food manufacturers. Perceptions of risks arising from biotechnology are proxied by variables representing respondent beliefs about whether biotechnology and genetic engineering is risky, whether new diseases are likely to emerge because of biotechnology research, and whether biotechnology will reduce the range of fresh foods available. In each of these cases, an increase in the variable is expected to have a negative impact on trust.

The trustworthiness of biotechnology institutions is proxied by a variable indicating whether respondents believe current regulations are sufficient to protect people from risks and a variable indicating whether respondents believe the biotechnology industry can self-regulate. Each of these variables is expected to be positively correlated with improved trustworthiness of university scientists and food manufacturers, suggesting they should positively affect trust in these biotechnology institutions. Competence is proxied by a variable indicating whether respondents agree that biotechnology is too complex to be adequately regulated, and by a variable indicating whether respondents agree it is not worth labeling genetically modified (GM) food. Because a reduction in perceived competence is anticipated to lower trust, the variable measuring complexity and regulation is expected to be negative, while the variable representing attitudes toward food labeling is expected to be positive. (In the latter case, the justification for the labeling variable is that if respondents do not perceive a need to distinguish between GM and non-GM foods by means of labels—perhaps because they consider the issue of genetically modified food not complicated enough to warrant separate labels—then they may not be overly concerned about the competence of biotechnology institutions to separate GM from non-GM foods or engage in other activities reflecting or affected by competence.)

The Support Model

Equation (3) describes the relationship between public support and trust, controlling for the expected endogeneity of trust and other factors likely to affect support. Public support for biotechnology is proxied by a dichotomous variable equal to one if respondents expressed support rather than opposition to biotechnology in agriculture and food production. As observed in table 1, approximately three-quarters of respondents expressed support for biotechnology.

Siegrist (2000) and Rosati and Saba (2000) reported that increases in perceived risks tend to reduce public acceptance, while increases in the expected benefits of biotechnology research improve public acceptance (Wolt and Peterson, 2000; Hampel, Pfenning, and Peters, 2000). Therefore, variables are included to represent respondent beliefs that biotechnology will improve life and that biotechnology is risky. Additionally, Rosati and Saba (2000) found that uncertainty regarding biotechnology and moral beliefs affected public acceptance, and Priest, Bonfadelli, and Rusanen (2003) concluded that attitudes toward science, knowledge of science, and education level have separate, distinct effects on support for biotechnology. Hence, a variable measuring the strength of the respondent's religious beliefs is included, as well as variables measuring beliefs about how important biotechnology is to the respondent, how informed the respondent is about biotechnology, and whether the respondent has negative feelings toward biotechnology. Finally, a variable is included to indicate the level of the respondent's understanding about biotechnology and genetic engineering.

Results

Table 2 presents the results of the probit analysis of equation (1), in which trust in scientists and trust in food manufacturers are regressed on variables representing benefits, costs, trustworthiness, and competence—factors expected to be important for trust. Table 3 reports the results of the probit analysis of equation (3), in which a measure of public support for biotechnology is regressed on predicted trust in scientists and food manufacturers, controlling for other factors expected to affect support. The estimated slope, which represents the change in the probability of the dependent variable for a unit change in the explanatory variable, is calculated by multiplying the estimated coefficient by the average density function of the standard normal distribution evaluated for each observation (Greene, 2000).

As revealed by table 2, few variables affect trust of scientists. Indeed, the only variables significantly correlated with trust in scientists are perceptions of whether biotechnology will improve life and beliefs that current regulations are sufficient to regulate biotechnology institutions. Specifically, perceived benefits and expectations of trustworthiness alone are key factors explaining trust in scientists. However, the effect of these two variables is relatively small, improving trust by approximately 5% each.

In contrast, trust in food manufacturers is affected by variables representing perceived benefits, perceived costs, expectations of trustworthiness, and expectations of competence, as predicted. For example, perceptions that biotechnology will result in improved life, reduced pollution, and reduced world hunger increase trust in food manufacturers by 8.7%, 5.7%, and 9.9%, respectively, while perceptions that biotechnology is risky lowers trust by nearly 10%. Moreover, expectations of trustworthiness appear to be particularly important for trust in food manufacturers. For instance, respondents who believe the biotechnology industry can regulate itself (e.g., the industry is trustworthy) show a 19% increase in trust in food manufacturers, relative to respondents who do not believe the industry can self-regulate. Finally, expectations of competence also appear to be important for trust in food manufacturers, as suggested by the finding that respondents who believe it is not worth labeling GM foods are 8.6% more likely to trust food manufacturers than respondents who believe GM foods should be labeled.

Table 2. Probit Regression Results for Trust in Scientists and Trust in Food Manufacturers

Variable	Trust in Scientists		Trust in Food Manufacturers	
	Coefficient (Std. Error)	Estimated Slope	Coefficient (Std. Error)	Estimated Slope
Intercept	1.1734** (0.4871)	0.1890	!0.5011 (0.3496)	!0.1806
Will Improve Life	0.3039*** (0.1137)	0.0490	0.2413*** (0.0843)	0.0870
Will Reduce Environmental Pollution	0.1266 (0.1169)	0.0204	0.1567* (0.0859)	0.0565
Will Reduce World Hunger	0.0355 (0.1189)	0.0057	0.2742*** (0.0855)	0.0988
Too Risky	!0.1969 (0.1244)	!0.0317	!0.2765*** (0.0969)	!0.0997
Likely to Result in New Diseases	!0.1042 (0.1244)	!0.0168	!0.0964 (0.0879)	!0.0348
Likely to Reduce Range of Foods	!0.0330 (0.1142)	!0.0053	!0.0088 (0.0839)	!0.0031
Current Regulations Sufficient	0.3446*** (0.1304)	0.0555	0.2661*** (0.0880)	0.0959
Industry Can Self-Regulate	0.0644 (0.1544)	0.0104	0.5399*** (0.1137)	0.1946
Too Complex for Policy	!0.1598 (0.1420)	!0.0257	!0.1161 (0.1109)	!0.0419
Not Worth Labeling	0.1263 (0.1638)	0.0203	0.2373** (0.1139)	0.0855
College	0.0433 (0.1159)	0.0070	!0.1400* (0.0848)	!0.0505
Male	!0.1404 (0.1123)	!0.0226	0.0822 (0.0815)	0.0296
Age	0.0048 (0.0196)	0.0008	0.0061 (0.0143)	0.0022
Age Squared	!0.0001 (0.0002)	!0.00002	0.0000 (0.0001)	0.0000
Pseudo R^2	0.0705		0.1424	
Likelihood Ratio (df = 14)	35.4504***		119.1647***	
% Corrected Predicted	66.5%		68.2%	
Average Density	0.1611		0.3605	

Notes: Single, double, and triple asterisks (*) denote statistical significance at the 10%, 5%, and 1% levels, respectively. Estimated slope is calculated by multiplying the coefficient by the average density.

Table 3. Probit Analysis Results of Support of Biotechnology, Controlling for Trust and Other Factors

	MODEL 1 (Effect of Trust in Scientists)		**MODEL 2** (Effect of Trust in Food Manufacturers)	
Variable	Coefficient (Std. Error)	Estimated Slope	Coefficient (Std. Error)	Estimated Slope
Intercept	! 4.9532***	! 1.3037	! 0.8378*	! 0.2198
	(1.2883)		(0.4748)	
Trust Scientists (predicted)	5.5762***	1.4677		
	(1.3187)			
Trust Food Manufacturers (predicted)			1.8161***	0.4765
			(0.3834)	
Will Improve Life	0.0423	0.0111	0.1687	0.0443
	(0.1246)		(0.1059)	
Too Risky	! 0.3481***	! 0.0916	! 0.3737***	! 0.0981
	(0.1195)		(0.1133)	
Religious	! 0.0053	! 0.0014	! 0.0113	! 0.0030
	(0.0175)		(0.0175)	
Biotechnology Is Important	0.0564**	0.0148	0.0610**	0.0160
	(0.0251)		(0.0251)	
Informed About Biotechnology	0.0776***	0.0204	0.0793***	0.0208
	(0.0268)		(0.0270)	
Negative Feelings About Biotechnology	! 0.2802**	! 0.0737	! 0.2775**	! 0.0728
	(0.1259)		(0.1257)	
Knowledge of Basic Genetic Science	0.1038***	0.0273	0.1052***	0.0276
	(0.0268)		(0.0268)	
College	0.0536	0.0141	0.2249**	0.0590
	(0.0964)		(0.1009)	
Male	0.3153***	0.0830	0.1361	0.0357
	(0.0985)		(0.0962)	
Age	! 0.0355**	! 0.0093	! 0.0323*	! 0.0085
	(0.0171)		(0.0171)	
Age Squared	0.00047***	0.00012	0.00033*	0.00008
	(0.00018)		(0.00018)	
Pseudo R^2	0.2250		0.2311	
Likelihood Ratio (df = 12)	168.6100***		173.5975***	
% Corrected Predicted	76.5%		76.6%	
Average Density	0.2632		0.2624	

Notes: Single, double, and triple asterisks (*) denote statistical significance at the 10%, 5%, and 1% levels, respectively. Estimated slope is calculated by multiplying the coefficient by the average density.

Based on the results reported in table 3, trust in scientists and food manufacturers has an important effect on public support for biotechnology, even after controlling for the endogeneity of trust as well as other factors expected to affect public support. Indeed, of the variables included in this analysis, trust has the largest effect on public support. For instance, according to the results reported under model 1, which examines the effect of trust in scientists, a one standard deviation increase in the trust of scientists improves public support for biotechnology by 43%.[3] Similarly, the results reported under model 2, which examines the effect of trust in food manufacturers, indicate a one standard deviation in trust in food manufacturers improves public support by nearly 24%.[4]

Interestingly, the analysis reveals that trust in scientists appears to have a comparatively larger effect on public support for biotechnology than trust in food manufacturers, despite the few factors affecting this trust (table 2). Additionally, perceptions that biotechnology is risky lower public support, as do negative feelings for biotechnology. In contrast, respondents who believe biotechnology is important, who are informed about biotechnology, who do not have negative feelings toward biotechnology, or who have a basic knowledge of genetic science are more likely to support biotechnology. While significant, a belief that biotechnology is important and being informed about biotechnology produce only a small increase (e.g., between 1% and 2% each) in support. In contrast, one's feelings regarding biotechnology affect support for it by more than 7%. Furthermore, a one standard deviation increase in knowledge of basic genetic science increases support for biotechnology by approximately 5%.

Discussion

To summarize the findings of this analysis of the U.S. Biotechnology Study, respondents place relatively high trust in scientists, while trust in food manufacturers is only moderate. Very few variables are correlated with trust in scientists, while variables reflecting perceived benefits and costs, and expectations of trustworthiness and competence, collectively explain trust in food manufacturers. Finally, trust in scientists has a stronger effect on public support for biotechnology than trust in food manufacturers.

These findings are curious. One explanation could come from Uslaner's (2002) distinction between generalized and particularized trust. *Generalized* trust is trust placed in most people; it is relatively stable and is largely unaffected by other factors, such as regression covariates. This is in contrast to *particularized* trust, which is trust placed in specific institutions or institutions associated with certain characteristics. As such, particularized trust would be affected by institutions or

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[3] A one standard deviation increase in trust in scientists, 0.2955 (from table 1), multiplied by the percentage increase in public support per unit change in trust, 1.4677 (table 3), equals 43.4%.

[4] A one standard deviation increase in trust in food manufacturers, 0.4976 (from table 1), multiplied by the percentage increase in public support per unit change in trust, 0.4765 (table 3), equals 23.7%.

individual characteristics, and hence would be relatively more affected by covariates than generalized trust. This characterization fits the data presented here, since not only are few variables (e.g., only two in this study) correlated with trust in scientists, but also most people trust scientists—and the variability (mean adjusted standard deviation) in that trust is low, especially when compared to trust of food manufacturers. Thus, trust in scientists might be relatively more *generalized* than trust in food manufacturers.

According to Uslaner (2002), generalized trust is important for the development of social capital, which in turn is necessary for the functioning of democratic and market-oriented societies. Consequently, if trust in scientists is generalized, then trust in scientists should have important benefits to society *generally*, especially in the context of potentially controversial issues such as biotechnology research and applications to food, medicine, and other consumer products. The data appear to be consistent with this argument. Trust in scientists has a comparatively larger effect on public support for biotechnology than trust in food manufacturers (see table 3). This will likely have important implications for the public support of biotechnology, since information the public receives about biotechnology often comes from the scientists engaged in the research. This finding is also consistent with previous investigations showing that scientists are regarded by both the public and other scientists as most likely to tell the truth about biotechnology (see Lang, O'Neill, and Hallman, 2004; Lang and Hallman, 2005). Hence, even if there are negative stories about biotechnology (e.g., reports of GM contamination of non-GM foods or crops), information reported by scientists might still be regarded as reliable.

In contrast, trust in food manufacturers is affected by a full range of variables reflecting public perceptions of risks and benefits, as well as perceptions of trustworthiness and competence, suggesting trust in food manufacturers is *particularized*—i.e., it is affected by specific institutional or individual characteristics. This is not too surprising, since it is from food manufacturers that we get our food. Survey respondents *qua* consumers are closer to food manufacturers than to scientists along the value chain, and food manufacturers probably have a greater impact on food safety than scientists, implying that public perceptions of risks, benefits, trustworthiness, and competence ought to be more salient in the case of food manufacturers than for scientists.

While perceived risks and benefits are important, perceptions of trustworthiness and competence are especially important in the case of particularized trust, since these are *necessary*, though not sufficient, for trust formation. By *necessary*, it is meant that if one is absent, trust will not exist; however, the presence of either aspect does not guarantee the existence of trust. Thus, any information (related to biotechnology or not) calling into question the perceived trustworthiness *or* competence of food manufacturers could reduce public trust in them with respect to biotechnology (Slovic, 1993). For instance, public announcements of biotechnology problems (such as GM contamination of human food products) can have negative impacts on trust, even though the trustworthiness of biotechnology institutions is not an issue.

Conversely, questions of trustworthiness, which might arise because of corporate accounting scandals of both biotechnology and non-biotechnology companies, could also destroy trust, independent of the perceived competence of the firms and the actual risks and benefits of biotechnology. Therefore, in order to foster public trust, and hence foster public support for biotechnology, food manufacturers should be particularly careful in the actions they take so that perceptions of trustworthiness and competence are strengthened rather than weakened.

This study has also shown that trust in scientists and trust in food manufacturers have a large and important effect on public support for biotechnology. Indeed, trust is shown to be more important than perceptions of risks or benefits a*lone*. This finding is in contrast to other studies reporting a weak link between trust and public support. There are several possible explanations for this finding. First, because much of the previous empirical work on the trust and support relationship is based on European data, there might be differences between U.S. and European respondents with respect to public trust and support. Indeed, U.S. consumers are generally more accepting of biotechnology than Europeans (Sittenfeld and Espinoza, 2002), and these differences are likely apparent in how survey respondents answer questions regarding trust and public support. Second, previous research may not have accurately identified and corrected for an expected endogenous relationship between trust and public support for biotechnology (James, 2003). A third explanation is that studies examining the trust and support relationship use different measures of trust. For example, Priest, Bonfadelli, and Rusanen (2003) measure trust as a belief that the entity is “doing a good job for society.” This is in contrast to the direct measure of trust used here, defined as the respondent having a lot or some trust in a statement by the entity about biotechnology. Unfortunately, there is no generally accepted definition of trust, which is problematic with research designed to examine the relationship between trust and other factors.

Concluding Comments

Given the inevitably increasing scientific advances of biotechnology research, an understanding of the relationship between trust and public support is important in guiding the social debate over GM foods and the role of biotechnology in food production. If public trust is a factor affecting public support for biotechnology, and if it is as varied and important as this research suggests, then more effort should be placed on examining (*a*) what it means to say there is trust in biotechnology institutions; (*b*) how trust ought to be measured; (*c*) why trust in biotechnology institutions is or is not affected by perceptions of risks, benefits, trustworthiness, and competence; and (*d*) whether the relationship between trust and public support, as well as factors affecting trust and public support, change over time.

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