The Effect of Trust on Public Support for Biotechnology: Evidence from the U.S. Biotechnology Study, 1997-1998

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Abstract: The purpose of this paper is to examine the extent to which trust directly affects public support for biotechnology, particularly in applications to food production and genetic modification of crop plants. Unlike previous research in which trust is assumed to be exogenous, this paper posits that trust is endogenously determined. An econometric model is developed that controls for the endogeneity of trust using instrumental variable and selection correction techniques. Using data from the U.S. Biotechnology Study, this study finds that the effect of trust on public support is substantially stronger than previous estimates.

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1. Introduction

The success of the commercial biotechnology industry depends fundamentally on society's acceptance of the genetic modification of crop plants and the use of biotechnology in food production (Frewer, Howard, and Aaron, 1998). The reason is straightforward: If the public does not accept or support the use of biotechnology in the development and production of food and related agricultural products, then consumers will not want to purchase those products. Public trust might be an important factor contributing to the commercial success of biotechnology. First, experimental evidence shows that trust in the source of information about biotechnology risks and benefits increases an individual's intention to purchase products derived from biotechnology (Finlay, Morris, Londerville, and Guelph, 1999). Second, persistent consumer concerns and low public support for biotechnology are often viewed as signs of a lack of public trust (Brom, 2000; Hampel, Pfenning, and Peter, 2001; see also Slovic, 1993; Levi, 2000).

The role of trust in fostering public support is particularly important in the context of risk communication (Hunt and Frewer, 2001). This is because consumers perceive that biotechnology institutions have a "reporting bias" (i.e., an incentive to overstate benefits and understate risks) and a "knowledge bias" (i.e., an inability to fully anticipate all contingencies) when publicly communicating the risks and benefits of biotechnology research (see Dholakia and Sternthal, 1997; Eagly, Wood, and Chaiken, 1978). As a result, information reported by biotechnology institutions will be discounted by the public, especially statements regarding possible risks associated with consumer applications of biotechnology research. Because public perceptions of risks and benefits affect the confidence consumers place in emerging technologies (Kasperson, Golding, and Tuler, 1992; Peters, Covello, and McCallum, 1997), such perceptions also affect the public's willingness to support institutions developing new technologies, such as biotechnology industries (Frewer, Howard, and Aaron, 1998).

Slovic (1993) argues that negative public perceptions can be mitigated by public trust. Hence, public trust should improve public support for biotechnology, other things being equal. However, empirical evidence linking trust to public support for biotechnology and genetic engineering is mixed. On the one hand, Frewer and Shepherd (1994) and Finlay et al (1999) conducted experiments in which subjects were exposed to different types of information about biotechnology. They found that trust in information sources had no significant effect on support for biotechnology, except, interestingly, in increasing purchase intent (Finlay et al). On the other hand, Rosati and Saba (2000) and Siegrist (2000) used survey data to find a positive effect of trust. For example, Rosati and Saba used a sample of 434 Italian respondents to study how public acceptance of biotechnology is affected by trust, perceived risks, benefits, uncertainty, and the respondent's moral beliefs about biotechnology. They found that trust had a positive and significant effect on acceptance, although trust was the weakest of the five variables tested in their model. Siegrist (2000), however, found a more significant, though indirect, effect of trust on public support. He hypothesized that trust in institutions using biotechnology affects the perceived benefits and risks associated with biotechnology, which in turn affects the public acceptance of biotechnology research. He tested his model using information from 1001 randomly sampled Swiss citizens and found that the model was consistent with the data. Although the survey data provides positive support for the hypothesis that trust affects public support for biotechnology, in reality the evidence is marginal at best – Rosati and Saba showed that trust is the weakest of the five variables examined, and Siegrist documented only an indirect effect of trust on public support.

The purpose of this study is to examine the effect of trust on public support for biotechnology. The paper begins with the premise that trust is not an "exogenous" variable affecting public support as presumed in previous studies, in part because trust involves cognitive processes. According to Hardin (2001), although some trust might be noncognitive in that people just have a disposition to trust or not trust, "one is most likely to have first made a cognitive selection of *whom* to trust" (p. 6; emphasis in original). Thus, understanding why people trust and what factors affect that trust is an important part of the problem of assessing the impact of trust on public support for biotechnology institutions. In effect, this requires that trust be treated as an endogenous rather than exogenous factor in models of public support for biotechnology. If the endogeneity of trust is not controlled for, then empirical estimates of the effect of trust on biotechnology support will be biased. In fact, a failure to control for the endogeneity of trust might explain the mixed evidence found in previous studies (cited above) linking trust to public support. In this paper, data from the United States Biotechnology Study is used to examine the impact of trust on public support for biotechnology while controlling for the endogeneity of trust. This analysis finds that, after controlling for the endogeneity of trust, the impact of trust is more than four times stronger than uncorrected estimates. Moreover, trust is shown to have a stronger impact than perceived risks from biotechnology research, expected benefits, and all other variables examined. This suggests that trust might be a more important factor affecting society's acceptance of biotechnology research than previously recognized.

2. Trust and the Estimation of the Trust Effect

Trust can be viewed as an expectation that one would not be exploited by another (James, 2002a). Thus, "uncertainty and vulnerability are the core elements of trust relations" (Heimer, 2001, p. 43). To say that trust affects the public support of biotechnology means that individuals who trust biotechnology institutions in the development of agricultural products or applications will not expect to be exploited in the sense that such products or applications are ultimately determined to be unsafe or ineffective. This expectation is based on the perceived trustworthiness (i.e., the "reporting bias") and competence (i.e., the "knowledge bias") of the biotechnology institutions (see James, 2002a; Levi, 2000). That is, if the public is confident that it would not be exploited (e.g., the public perceives biotechnology institutions to be trustworthy and competent), then the public would be more likely to trust and, in turn, support biotechnology institutions. However, if the public expects to be exploited (e.g., public perceptions are that biotechnology institutions have a vested interest to misrepresent the safety and efficacy of biotechnology or have insufficient knowledge to conduct biotechnology-based research and development), then the public would be less willing to trust and hence support biotechnology institutions (see Hunt and Frewer, 2001).

The equation that models the direct effect of trust on the public support of biotechnology institutions is

(1) $$S_i = \beta' X_i + \delta T_i + u_i ,$$

where S_i is the measure of public support, β is a vector of parameters, X_i is a vector of other explanatory variables, 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 $i = 1 \ldots N$. Does the parameter δ accurately measure the effect of trust on public support? Earlier empirical studies answer this question by estimating the size and significance of δ in models structurally similar to equation (1). These estimates of δ, however, will not accurately measure the effect of trust on public support for biotechnology if trust is a decision variable reflecting, for instance, the public's expectations of the trustworthiness and competence of biotechnology institutions. The reason is that if trust (T_i) and public support (S_i) are dependent variables, then the variable T_i in equation (1) will be correlated with the error term u_i. The implication is that regression estimates of δ will not correctly describe the effect of trust on public support for biotechnology research.

In order to model correctly the relationship between trust and public support of biotechnology, a separate equation is required in which trust is the dependent variable. Coleman (1990) and James (2002b) develop models of trust in which the decision to trust is based on an examination of the expected gains from correctly trusting relative to the expected losses from mistrusting (i.e., when trust is exploited). If T_i^B is the expected benefit when individual i trusts biotechnology institutions, and T_i^L is the expected loss from mistrusting (e.g., when biotechnology products or applications are determined to be unsafe or ineffective), then a person would trust if $T_i^B > T_i^L$. That is, we observe $T_i = 1$ if $T_i^B > T_i^L$; conversely, $T_i = 0$ if $T_i^B \le T_i^L$. The decision to trust can therefore be modeled by the equation

(2) $$T_i = \gamma' Z_i + \varepsilon_i \,,$$

where γ is a vector of parameters, Z_i is a set of explanatory variables, and ε_i is the error term, such that

$$T_i = 1 \text{ iff } \varepsilon_i > -\gamma' Z_i$$

$$T_i = 0 \text{ otherwise.}$$

According to Coleman (1990) and James (2002b), the set of explanatory variables, Z_i, would include elements representing an individual's assessments of the potential losses from being exploited, the potential gains from correctly trusting, and the probability of not being exploited because of untrustworthiness or incompetence. Specifically, the probability that a person would trust (i.e., $prob(\varepsilon_i > -\gamma' Z_i)$) increases when the losses from misplaced trust decrease, the gains from correctly trusting increase, and the probability that trust will not be exploited increases, other things being equal.

If equation (1) is estimated without correcting for the endogeneity of trust modeled by equation (2), then the error terms u_i and ε_i will be correlated resulting in the biased estimation of δ in equation (1). Vella and Verbeek (1999) explain that there are two approaches to estimating correctly models such as equation (1), in which an explanatory variable is also a dependent variable modeled by equation (2). One approach is to replace T_i in equation (1) with an instrumental variable expected to be correlated with S_i but not correlated with the error term u_i. The other approach is to correct for the endogeneity of T_i by including a selection-correcting factor, λ_i, in equation (1), consistent with the work of Heckman (1979).

According to the instrumental variable approach, two steps are followed. First, equation (2) is estimated with a Probit analysis, and then the predicted probabilities of T_i, denoted as $\hat{T}_i$, are inserted in equation (1) in place of T_i. These fitted values for T_i will be correlated with S_i but not with u_i (see Greene, 2000, ch. 9). Second, the effect of trust on public support, δ, is determined by estimating the following corrected version of equation (1):

(3) $$S_i = \beta' X_i + \delta \hat{T}_i + \mu_i \,.$$

According to the selection correction approach, the correction factor necessary to resolve the endogeneity of T_i is identified by recognizing that the conditional expectation of S_i when $T_i = 1$ (that is, when $\varepsilon_i > -\gamma' Z_i$) is

(4a)
$$E(S_i \mid \varepsilon_i > -\gamma' Z_i) = \beta' X_i + \delta + E(u_i \mid \varepsilon_i > -\gamma' Z_i)$$
$$= \beta' X_i + \delta + \rho\sigma_u \frac{\phi(-\gamma' Z_i)}{1 - \Phi(-\gamma' Z_i)},$$

and the conditional expectation of S_i when $T_i = 0$ is

(4b)
$$E(S_i \mid \varepsilon_i \le -\gamma' Z_i) = \beta' X_i + E(u_i \mid \varepsilon_i \le -\gamma' Z_i)$$
$$= \beta' X_i + \rho\sigma_u \frac{-\phi(-\gamma' Z_i)}{\Phi(-\gamma' Z_i)},$$

where $\phi(\cdot)$ is the density function and $\Phi(\cdot)$ is the cumulative density function of the standard normal distribution, ρ is the correlation of the error terms u_i and ε_i, and σ_u is the standard deviation of u_i. The terms $\frac{\phi(-\gamma' Z_i)}{1 - \Phi(-\gamma' Z_i)}$ and $\frac{-\phi(-\gamma' Z_i)}{\Phi(-\gamma' Z_i)}$ in equations (4a) and (4b) respectively are "inverse Mill's ratios," and they are required to correct for the selection bias of equation (1) (see Greene, 2000, ch. 20; Vella and Verbeek, 1999; Maddala, 1983). In order to make the selection bias correction, two steps are followed. First, equation (2) is estimated using Probit analysis and an estimate of $\hat{\lambda}_i(\hat{\gamma}' Z_i)$ is obtained, where $\hat{\gamma}' Z_i$ is the predicted value from equation (2), and

(5)
$$\hat{\lambda}_i(\hat{\gamma}' Z_i) = \frac{\phi(-\hat{\gamma}' Z_i)}{1 - \Phi(-\hat{\gamma}' Z_i)} \text{ if } T_i = 1$$
$$\hat{\lambda}_i(\hat{\gamma}' Z_i) = \frac{-\phi(-\hat{\gamma}' Z_i)}{\Phi(-\hat{\gamma}' Z_i)} \text{ if } T_i = 0.$$

Second the effect of trust on public support, δ, is determined by estimating the following corrected version of equation (1):

(6)
$$S_i = \beta' X_i + \delta T_i + \theta \hat{\lambda}_i(\cdot) + \eta_i,$$

in which $\hat{\lambda}_i(\cdot)$ is added as a regressor. In this model, the coefficient θ has an important economic interpretation. If $\theta > 0$, then individuals who are willing to support biotechnology research will do so whether or not they trust, or even in the absence of trust (characterizing a *hierarchal* structure to the relationship between trust and support). However, if $\theta < 0$, then public support is higher because individuals trust biotechnology institutions (characterizing a *comparative advantage* structure to the trust-support relationship) and thus, without trust, public support will be lower. In other words, $\theta > 0$ indicates that the effect of trust is overestimated in models such as equation (1) that do not include a correction factor, while $\theta < 0$ indicates that the effect of trust is underestimated without the correction. Note that from a theoretical perspective, the expected sign of θ is ambiguous. However, because it is hypothesized that trust is an important factor affecting the public acceptance of biotechnology research, the sign of θ is expected to be negative and significant, indicating that uncorrected models underestimate the impact of trust on public support for biotechnology.

3. Data

The effect of trust on public support for biotechnology research, particularly in applications to food and agricultural production, was examined using data from the United States Biotechnology Study, 1997-1998 (see Miller, 2000), created from telephone interviews of 1,067 randomly sampled U.S. citizens, 18 years of age and older, between November 1997 and February 1998. In this sample, 49.8 percent of respondents were male, 58.7 percent of respondents had at least some post high school education, and the average respondent was 45 years old. Respondents were asked a variety of questions, including questions regarding their knowledge of and attitudes towards biotechnology, their understanding of biotechnology science, their interest in biotechnology news, and their confidence in scientists and institutions engaged in biotechnology research.

In order to examine the effect of trust on public support for biotechnology, measures of public support and public trust were created, in addition to a set of control variables. The measures of public support for the use of biotechnology in the production of food and drinks (SBIOFOOD) and the use of genetic modification of crop plants (SBIOPLANTS) were based on Gaskell's (2000) definition of support. According to this definition, individuals support biotechnology if they believe that it is (a) useful, (b) morally acceptable, and (c) should be encouraged. Therefore, respondents were coded as supporting the use of biotechnology in the production of food and drinks (SBIOFOOD=1) if they reported that they definitely agree or tend to agree that the "use of modern biotechnology in the production of food and drinks" (a) "is useful," (b) "is morally acceptable," and (c) "should be encouraged" (SBIOFOOD=0 otherwise). Similarly, respondents were coded as supporting genetic modification of crop plants (SBIOPLANTS=1) if they reported that they definitely agree or tend to agree that "using biotechnology to insert genes from one plant into a crop plant" (a) "is useful," (b) "is morally acceptable," and (c) "should be encouraged" (SBIOPLANTS=0 otherwise). Respondents were coded as trusting biotechnology institutions (TRUST=1) if they placed a lot or some confidence in university scientists and food manufacturers (TRUST=0 otherwise). As shown in Table 1, which presents the sample means and standard deviations for all variables used in this study, 51.2 percent of respondents sampled support biotechnology applications in food and drink production, and 60.4 percent support the genetic modification of crop plants. That respondents are relatively more supportive of genetic modifications to crop plants than biotechnology applications in food production is consistent with the findings of Hoban (1998), Gaskell (2000), and Hampel et al (2000). Moreover, nearly 53 percent of respondents place at least some trust in biotechnology institutions.

In addition to TRUST as an explanatory variable, the other variables expected to affect public support for the use of biotechnology in food production (SBIOFOOD) and the genetic modification of crop plants (SBIOPLANTS), were identified based on the earlier studies linking trust to support (cited above). These variables are the following (sample means and standard deviations in Table 1):

- RISKYBFOOD: A dummy equal to one if the respondent definitely agreed or tended to agree that the use of biotechnology in the production of food and drinks is risky to society; zero otherwise.
- HEARDBFOOD: A dummy equal to one if the respondent had heard of the use of biotechnology in the production of food and drinks; zero otherwise.

- RISKYBPLANTS: A dummy equal to one if the respondent definitely agreed or tended to agree that using biotechnology to insert genes from one plant into a crop plant is risky to society; zero otherwise.

- HEARDBPLANTS: A dummy equal to one if the respondent had heard of using biotechnology to insert genes from one plant into a crop plant; zero otherwise.

- IMPROVELIFE: A dummy equal to one if the respondent believed that biotechnology or genetic engineering will improve our way of life in the next 20 years; zero otherwise.

- NEGFEEL: A dummy equal to one if the respondent has strongly negative or negative feelings about modern biotechnology; zero otherwise.

- UNDERSTAND: A dummy equal to one if the respondent correctly answered each of the following three True/False biotechnology-related questions: (1) DNA regulates inherited characteristics in all plants, animals, and humans (correct answer True); (2) Ordinary tomatoes do not contain genes while genetically modified tomatoes do (correct answer False); and (3) By eating a genetically modified fruit, a person's genes could also become modified (correct answer False); zero otherwise.

- COLLEGE: A dummy equal to one if the respondent had completed some college degree; zero otherwise.

- MALE: A dummy equal to one if the respondent is male; zero otherwise.

- TRUST_HAT: The predicted probability for T_i, denoted as $\hat{T}_i$, from the estimation of equation (2).

- LAMBDA: The selection correction factor, obtained by calculating the inverse Mill's ratios using the fitted values of $\hat{\gamma}' Z_i$ from the estimation of equation (2).

In order to make predictions on the expected signs of the effect of the independent variables on public support, note that 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 (see also Wolt and Peterson, 2000; Gaskell, 2000; Hampel, Pfenning, and Peters, 2000). Therefore, the coefficients on the risk variables RISKYBFOOD and RISKYBPLANTS are expected to be negative, while the coefficient on IMPROVELIFE, which measures the perception that biotechnology will result in social benefits, is expected to be positive. Additionally, Rosati and Saba (2000) found that an increased sense of uncertainty regarding biotechnology reduced public acceptance. In this study, uncertainty is proxied by the variable NEGFEEL – a greater sense of uncertainty felt by a respondent would likely translate into stronger negative feelings about biotechnology, thus reducing the degree to which biotechnology is supported; therefore, the coefficient for NEGFEEL is predicted to be negative. The expected signs of the variables HEARDBFOOD, HEARDBPLANTS, UNDERSTAND, and COLLEGE are not readily predictable, since the fact that respondents had heard of biotechnology or have an understanding of the science involved could indicate an interest in the issues, but not necessarily result in either support or lack of support for biotechnology research. The coefficient on MALE is expected to be positive because other researchers (Hampel et al, 2000; Siegrist, 2000) have found that men are generally more accepting of biotechnology research than women.

In order to estimate equation (2), proxies for the potential losses and gains from placing trust in biotechnology, as well as the expected probability that such trust would be exploited, are required (see Coleman, 1990; James, 2002b). The potential loss resulting from misplaced trust in biotechnology institutions is proxied by the dummy variable RISKY, which takes the value of one if RISKYBF=1 and RISKYBP=1; zero otherwise. Increases in perceived risks (or losses) from biotechnology are expected to reduce trust (see Hunt and Frewer, 2001); therefore, the coefficient for RISKY is expected to be negative. The potential for gains is operationalized by the dummy variable PERSBNFT, which equals one if the respondent strongly agrees or agrees that biotechnology will personally benefit in the next 5 years, or has already personally benefited, himself or his family; zero otherwise. Individuals tend to trust when they have an interest in trusting (James, 2002b), perhaps because they expect to benefit personally from the biotechnology research (see Hunt and Frewer, 2001); therefore, the coefficient of PERSBNFT is expected to be positive. The respondent's assessment of the likelihood that trusting would be exploited is measured by the dummy variable GOVREGOK, which equals one if the respondent strongly agrees or agrees that "current regulations are sufficient to protect people from any risks linked to modern biotechnology;" zero otherwise. Individuals tend to trust if they believe the agent in whom they place trust has an incentive to be trustworthy (see James, 2002a, 2002b) and is competent (see Levi, 2000). In the case of biotechnology, respondents may be willing to trust if they perceive that biotechnology scientists and institutions are not motivated wholly by greed over the public interest and that they have the necessary knowledge to conduct biotechnology activities (see Hampel at al, 2000). This expectation could be created by the perception that behavior is sufficiently regulated; therefore, the coefficient on GOVREGOK is expected to be positive. In addition, COLLEGE and MALE were included in the trust equation to control for individual respondent characteristics.

4. Results

Table 2 presents the results of the Probit analysis of equation (2), in which TRUST is the dependent variable. The results indicate that the perception of risk reduces trust in biotechnology institutions, while the expectation of personal benefits and the belief that biotechnology institutions are sufficiently regulated support trust. Although the coefficient in a Probit model is not directly interpretable in terms of the magnitude of the effect on the probability of trust, it is possible to calculate the change in probability resulting from a change in the independent variable by multiplying the coefficient by the average density function of the standard normal distribution evaluated for each observation (Greene, 2000, ch. 19). This calculation creates the estimated slope parameters reported in column 3 of Table 2. Observe that the perception of risk reduces the probability of trust by 11.4 percent. Conversely, the expectation that biotechnology research will produce personal benefits increases the likelihood of trust by 22.1 percent. Similarly, the belief the biotechnology institutions are adequately regulated increases the probability of trust by 12.1 percent. Thus, it appears that trust in biotechnology would be improved by all three factors hypothesized to affect trust generally – reducing perceived risks, increasing perceived benefits, and ensuring that biotechnology institutions appropriate incentives for trustworthiness and competence.

Tables 3 and 4 present the results of the analysis of public support for biotechnology in the production of food and drink (SBIOFOOD), and public support for the genetic modification of crop plants (SBIOPLANTS), respectively, as functions of trust and other factors. Column 2 of Table 3 presents an estimation of equation (1) using ordinary least squares (OLS) regression analysis, in which SBIOFOOD (support for biotechnology in food production) is the dependent variable. In this linear probability formulation of the model, trust improves the likelihood of public support by nearly 16 percent.

However, because SBIOFOOD is a dichotomous variable, the linear probability (OLS) model produces biased estimates that are resolved through the use of a Probit analysis. In column 3 of Table 3, a Probit formulation of equation (1) is estimated, showing that trust increases the probability of public support by 15.4 percent. In addition, all other variables are significant, and for variables in which predictions are made, the signs are as expected. For example, if respondents believe that the use of biotechnology in food production is risky (RISKYBFOOD), then the probability of public support is reduced by more than 17 percent. Moreover, respondents who had heard of biotechnology applications in food production (HEARDBFOOD) show an increased probability of support of nearly 19 percent, and respondents who have an expectation that biotechnology will produce future benefits (IMPROVELIFE) increase public support by almost 13 percent.

Because trust is a dependent variable modeled by equation (2), the uncorrected Probit estimation of equation (1) presented in column 3 produces biased estimates of the effect of trust on public support for biotechnology in the production of food. Accordingly, corrections are required. In column 4 of Table 3, equation (3) is estimated in which the instrumental variable (IV), TRUST_HAT, is used in place of TRUST. In column 5, equation (6) is estimated, in which the selection correction factor, LAMBDA, is included as a regressor to control for the endogeneity of the trust variable. In both models, the effect of trust is to increase the probability of public support for biotechnology in food production by 66 percent, a more than fourfold increase compared to the uncorrected estimate of the trust coefficient obtained by the standard Probit analysis. Thus, corrected estimations of equation (1) show a significant improvement in the effect of trust on public support. Additionally, the coefficient on LAMBDA is significant and negative, suggesting the decision to trust is important and that uncorrected models underestimate the effect of trust on public support of biotechnology research. Because the coefficient on LAMBDA is negative and because the magnitude of the trust coefficient in the corrected estimates of equation (1) are substantially larger than the other coefficients, one cannot reject the hypothesis that individuals support biotechnology institutions in part because they trust the scientists and institutions engaged in biotechnology research.

An examination of the effect of trust and other factors on SBIOPLANTS (support for biotechnology research involving the genetic modification of plants), reported in Table 4, reveals similar findings. In the linear probability model estimated using OLS regression (column 2 of Table 4) and the Probit model (column 3), trust increases the probability of support by 10 percent. In comparison, when the endogeneity of trust is corrected, as in the IV (column 4) and selection factor (column 5) models, trust increases the probability of public support by 45 to 51 percent. Interestingly, risk becomes relatively more important, and the effect of trust less so, when biotechnology is applied to genetically modifying crop plants than producing food and drink products.

5. Conclusions

This study has examined the relationship between trust and public support of biotechnology institutions, particularly when biotechnology is applied to food production and when crop plants are genetically modified. In this study, trust is modeled as an endogenous rather than exogenous factor affecting public trust, in part because there is a cognitive aspect to the question of whether or not people trust biotechnology institutions. When the relationship between trust and public support for biotechnology is correctly modeled, using instrumental variables or selection-correction techniques to control for the endogeneity of trust, trust is found to be a more important determinant of public support than earlier studies indicate. Indeed, the estimated impact of trust increases at least fourfold when the endogenously corrected models of public support are compared to the uncorrected ones. To be precise, according to the data examined in this study from the U.S. Biotechnology Study, trust increases public support for biotechnology applications in food and drink production by 66 percent in models that control for the endogeneity of trust, while uncorrected models show the effect of trust to be roughly 15 percent. Similarly, corrected models linking trust to public support for the genetic modification of crop plants show that trust increases public support by between 45 and 50 percent, compared to the 10 percent effect estimated from the uncorrected models.

Additionally, the estimation of corrected models shows that trust is the most important factor affecting public support for biotechnology among the variables examined in this study, far exceeding the impact of perceived risks and benefits, for instance. This suggests that risk communication efforts to improve the public's perceptions of risks and benefits *alone* may not be fully effective in improving public support for biotechnology. Rather, efforts to increase public trust – or to be more precise, efforts to improve the perceived trustworthiness and competence of biotechnology institutions – might also be necessary in improving the public support for and acceptance of biotechnology research and applications in agribusiness activities. Clearly, more research is required in determining more precisely how trust and other factors affect public support and acceptance of biotechnology. For example, if the effect of trust on public support is endogenously determined, are there other factors affecting public support, such as perceived risks and benefits, that are also endogenous? In terms of public policy, which is more important – risk communication strategies to educate the public regarding the risks and benefits of biotechnology or efforts to improve public trust through institutional changes that improve the trustworthiness and competence of individuals working in biotechnology industries?

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Tables

Table 1. Sample Means and Standard Deviations for Variables

Variable	Mean	Standard Deviation
SBIOFOOD	.512	.500
RISKYBFOOD	.500	.500
HEARDBFOOD	.713	.452
SBIOPLANTS	.604	.489
RISKYBPLANTS	.387	.487
HEARDBPLANTS	.694	.461
IMPROVELIFE	.599	.490
NEGFEEL	.142	.350
UNDERSTAND	.379	.485
COLLEGE	.475	.500
MALE	.498	.500
TRUST	.529	.499
TRUST_HAT ($\hat{T}_i$)	.529	.145
LAMBDA ($\hat{\lambda}_i$)	0.000	.777
RISKY	.282	.450
PERSBNFT	.754	.431
GOVREGOK	.370	.483

Table 2. Probit Regression of Trust Model

Variable	Coefficient	Est. Slope
INTERCEPT	-0.363 [a] (0.100)	-0.135
RISKY	-0.308 [a] (0.088)	-0.114
PERSBNFT	0.597 [a] (0.094)	0.221
GOVREGOK	0.327 [a] (0.085)	0.121
COLLEGE	-0.192 [a] (0.080)	-0.071
MALE	0.086 (0.080)	0.032
Chi-Square (DF)	92.965[a] (5)	
Ave Density	.371	

Standard errors in parentheses.
Estimated Slope calculated by multiplying Coefficient with Density.
[a] significant at 1%; [b] significant at 5%; [c] significant at 10%

Table 3. Estimation of Models of Support of Biotechnology in Food and Drink Production

	OLS	Probit	Probit with IV	Probit with λ
Variable	**Coefficient**	**Coefficient**	**Coefficient**	**Coefficient**
INTERCEPT	0.163 [a] (0.040) [0.163]	-1.001 [a] (0.125) [-0.322]	-1.929 [a] (0.225) [-0.617]	-2.017 [a] (0.225) [-0.635]
RISKYBFOOD	-0.180 [a] (0.028) [-0.180]	-0.534 [a] (0.084) [-0.172]	-0.427 [a] (0.087) [-0.137]	-0.337 [a] (0.087) [-0.106]
HEARDBFOOD	0.194 [a] (0.031) [0.194]	0.579 [a] (0.094) [0.186]	0.582 [a] (0.094) [0.186]	0.609 [a] (0.092) [0.192]
IMPROVELIFE	0.137 [a] (0.029) [0.137]	0.399 [a] (0.088) [0.128]	0.367 [a] (0.089) [0.117]	0.317 [a] (0.088) [0.100]
NEGFEEL	-0.107 [a] (0.040) [-0.107]	-0.322 [a] (0.125) [-0.104]	-0.247 [b] (0.126) [-0.079]	-0.228 [b] (0.120) [-0.072]
UNDERSTAND	0.117 [a] (0.029) [0.117]	0.350 [a] (0.090) [0.113]	0.335 [a] (0.090) [0.107]	0.320 [a] (0.093) [0.101]
COLLEGE	0.114 [a] (0.029) [0.114]	0.340 [a] (0.088) [0.109]	0.476 [a] (0.093) [0.152]	0.551 [a] (0.098) [0.174]
MALE	0.104 [a] (0.027) [0.104]	0.314 [a] (0.084) [0.101]	0.258 [a] (0.085) [0.083]	0.297 [a] (0.085) [0.094]
TRUST	0.157 [a] (0.028) [0.157]	0.478 [a] (0.085) [0.154]	---	2.101 [a] (0.324) [0.662]
TRUST_HAT ($\hat{T}_i$)	---	---	2.076 [a] (0.328) [0.664]	---
LAMBDA ($\hat{\lambda}_i$)	---	---	---	-1.023 [a] (0.203) [-0.322]
Adjusted R^2	0.219	---	---	---
Chi-square (DF)	---	266.325[a] (8)	275.715[a] (8)	268.809[a] (8)
Ave Density	1.000	0.322	0.320	0.315

Standard errors in parentheses. Estimated slope calculated by multiplying coefficient with average density in brackets.

[a] significant at 1%; [b] significant at 5%; [c] significant at 10%

Table 4. Estimation of Models of Support for Genetic Modification of Crop Plants

	OLS	Probit	Probit with IV	Probit with λ
Variable	**Coefficient**	**Coefficient**	**Coefficient**	**Coefficient**
INTERCEPT	0.309 [a] (0.038) [0.309]	-0.566 [a] (0.115) [-0.182]	-1.280 [a] (0.218) [-0.410]	-1.264 [a] (0.220) [-0.398]
RISKYBPLANTS	-0.238 [a] (0.028) [-0.238]	-0.703 [a] (0.087) [-0.226]	-0.554 [a] (0.093) [-0.177]	-0.653 [a] (0.093) [-0.206]
HEARDBPLANTS	0.258 [a] (0.031) [0.258]	0.734 [a] (0.093) [0.236]	0.692 [a] (0.093) [0.221]	0.801 [a] (0.091) [0.252]
IMPROVELIFE	0.083 [a] (0.029) [0.083]	0.247 [a] (0.089) [0.080]	0.218 [b] (0.090) [0.070]	0.198 [b] (0.090) [0.062]
NEGFEEL	-0.019 (0.040) [-0.019]	-0.050 (0.122) [-0.016]	-0.002 (0.123) [-0.001]	-0.042 (0.117) [-0.013]
UNDERSTAND	0.117 [a] (0.030) [0.117]	0.370 [a] (0.093) [0.119]	0.372 [a] (0.094) [0.119]	0.425 [a] (0.097) [0.134]
COLLEGE	0.074 [a] (0.028) [0.074]	0.231 [a] (0.088) [0.074]	0.337 [a] (0.092) [0.108]	0.398 [a] (0.099) [0.125]
MALE	0.060 [b] (0.027) [0.060]	0.176 [b] (0.085) [0.057]	0.121 (0.087) [0.039]	0.159 [c] (0.087) [0.050]
TRUST	0.100 [a] (0.028) [0.100]	0.318 [a] (0.086) [0.102]	---	1.433 [a] (0.335) [0.451]
TRUST_HAT ($\hat{T}_i$)	---	---	1.589 [a] (0.336) [0.508]	---
LAMBDA ($\hat{\lambda}_i$)	---	---	---	-0.676 [a] (0.211) [-0.213]
Adjusted R^2	0.195	---	---	---
Chi-square (DF)	---	231.427[a] (8)	240.225[a] (8)	284.337[a] (8)
Ave Density	1.000	0.319	0.317	0.303

Standard errors in parentheses. Estimated slope calculated by multiplying coefficient with average density in brackets.
[a] significant at 1%; [b] significant at 5%; [c] significant at 10%