INTRODUCING FOODS PRODUCED USING BIOTECHNOLOGY: THE CASE OF BOVINE SOMATOTROPIN

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Abstract

A mailed questionnaire was used to assess consumer concerns and potential consumption response attributable to the introduction of bovine somatotropin (bST). Responses from 605 households in Virginia are described and analyzed. Logit models were estimated to identify which issues shape consumers' decisions to alter milk purchases contingent on the introduction of bST and to determine whether socioeconomic characteristics explain consumers' attitudes toward these issues. Estimates based on survey responses point toward sizable reductions in fluid milk purchases if bST is introduced. Large retail price reductions are predicted to be insufficient to offset these estimated decreases. Consumer education and marketing strategies are discussed.

Key words: bovine somatotropin, milk, demand, consumption, consumer attitudes

Since Griliches seminal study of technical change in agriculture, research on the diffusion of new agricultural technologies has focused on the farmer. Analysis of adoption by the immediate users is sufficient for most agricultural technologies, but not for a number of controversial biotechnologies under development for use in food production. The pace of diffusion and ultimately the fate of some emerging biotechnologies likely will be determined by agents other than farmers. Such actors include state and federal legislators, consumers, and various special interest groups.

As an example, consumers (or others acting in their name) may postpone the introduction of new biotechnologies by questioning the regulatory review process. Consequently, more scientific evidence on, say, human food safety issues may be required. Either generating new research or reviewing existing studies delays the regulatory approval process. More drastically, consumers may reject the products of a new biotechnology in the marketplace. If consumers shun foods produced using some biotechnological input, then the derived demand for the input at the farm level diminishes.

Bovine somatotropin (bST, also referred to as bovine growth hormone or bGH) is among the initial products of biotechnology nearing commercial introduction. Because of its precedent-setting importance, bST has become the focus of controversy over biotechnology. Opponents view the battle over bST as an opportunity to thwart the biotechnology industry in its incipiency. Likewise, proponents regard the outcome of bST in the legislative, regulatory, and market arenas as a key indicator of the prospects for future commercialization of other products of biotechnology.

A considerable amount of research has been conducted to analyze the economic impacts of bST adoption on the U.S. dairy industry (e.g., Blayney and Fallert; Fallert et al.; Kaiser and Tauer; Kalter et al.; Kimball and Rogers; Kinnucan et al.; Kronfeld, Kuchler, and McClelland; Marion and Wills; Sellschopp and Kalter; Zepeda). Much of the research has addressed production-related aspects of bST, such as costs of milk production, market prices for milk, aggregate and spatial impacts on dairy industry structure, adoption decisions, and dairy herd management. Potential shifts in demand, however, have largely been ignored in available *ex ante* assessments of marketwide consequences of bST approval and adoption. Changes in consumption have been assumed to result solely from price changes induced by outward shifts in the market supply function following the adoption of bST. Yet some of the more vocal opponents of biotechnology have attempted to mobilize consumer resistance to the introduction of bST as a technology for producing milk. Because the demand for dairy products is highly price inelastic (Haidacher et al.), even a small backward shift in the demand function could nullify the consumption response to a price decrease resulting from an increase in supply. Thus, there is a need to identify and quantify potential consumer responses to bST.

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PERSPECTIVE

During the late 1930s, scientists found that injecting cows with an extract from the bovine pituitary gland increased milk production (Bauman et al.). The British attempted to boost milk supplies during World War II by administering somatotropin to dairy cows, but the effort failed because several pituitary glands were needed to prepare a single daily dose of extract (Council for Agricultural Science and Technology). Research on bST was rekindled during the 1980s when recombinant DNA techniques enabled synthetic bST to be produced in the laboratory. Both daily and sustained release injections of synthetic bST have been shown to increase total milk production per lactation. Considerable variability in response has been found in long-term trials, ranging from a negligible negative response in one case to a nearly 45 percent increase in milk produced per lactation in another trial (Sellschopp and Kalter).

As with all new drugs for animals, bST requires approval by the Center for Veterinary Medicine within the Food and Drug Administration (FDA). Drug companies seeking approval must provide the FDA with data to demonstrate drug efficacy, animal safety, human food safety, environmental safety, and good manufacturing practices (Craigmill). The FDA concluded in 1985 that meat and milk from bST-treated cattle are safe for human consumption, and milk from cows involved in bST research has since been sold through regular commercial channels. Final approval of bST awaits completion of long-term studies on animal health as well as demonstration of environmental safety and good manufacturing practices. Experimental use of bST and its possible approval for commercial use have stirred negative reactions from both producer and consumer advocacy groups. Foes of bST contend that its introduction will cause large milk surpluses, force small dairy farmers out of business, and make milk supplies unsafe for human consumption. Also, some people believe that bST injections to cows are inhumane and that genetic engineering in general is dangerous and should not be used in food production.

Despite FDA regulatory review and approval of bST for investigational use in food production, adversaries have chosen human food safety as a focal point for waging a campaign against final approval and adoption of bST. At least one public health professional has challenged the conclusion that bST poses no public health threat (Epstein). To quell concerns about health risks associated with the use of bST in dairy cattle, the FDA released for independent peer review the details of the agency's human food safety evaluation of bST (Juskevich and Guyer). For a product not yet approved for commercial use, the FDA action was unprecedented.

Early in the development of bST, the dairy industry recognized that the potential existed for consumer backlash against use of the product. The National Dairy Board commissioned a study in 1986 to develop a strategy to communicate with consumers about the introduction of bST. Other commissioned studies include a mail survey for the trade magazine *Dairy Today* (Henderson), and face-to-face interviews in Great Britain (see CAES Consultants (Wye) Ltd.). Other surveys addressing attitudes about the use of bST (or more generally, genetic engineering) in milk production have been administered to consumers in Missouri (Slusher), New York (Kaiser et al.), North Carolina (Hoban), Pennsylvania (Smith), and Wisconsin (Douthitt).

The number of studies that have been initiated within a relatively short time frame shows that there is widespread interest in the issue of consumer attitudes toward bST. Clearly, analysis of consumer behavior will allow previously neglected demand-side effects to be included in impact studies of bST. Results would provide additional information for dairy industry participants in making decisions about the approval and adoption of bST. Further, such analysis would help dairy processors, product distributors, and retailers prepare appropriate marketing strategies to allay potential consumer backlash should bST be approved for commercial use. Finally, results would allow companies currently investing in biotechnology to develop more effective strategies for educating consumers about their products.

Accordingly, the purpose of this study was to assess consumer attitudes about bST and to determine potential consumption response to the approval of bST for commercial use in dairy herds. To fulfill this objective, several critical questions were addressed: (1) To what extent will the demand for milk be affected by the introduction of bST, given different retail milk price scenarios? (2) To what extent do demographic characteristics explain potential milk consumption response contingent on the introduction of bST? (3) Which issues regarding the use of bST in milk production concern consumers the most? (4) To what extent do demographic characteristics explain consumers' concerns about issues surrounding the introduction of bST?

DATA

A four-page questionnaire was developed to measure attitudes and elicit consumer response to the possible commercial adoption of bST.[1] Despite considerable publicity about bST in the media, expecta-

tions were that many consumers would not be familiar with the technology. Hence, the first half-page of the survey instrument presented a description of bST technology, written in the form of a short newspaper article. To determine whether consumers' responses could be influenced by the manner in which information is presented, two versions of the description were developed (see appendix).[2] The "neutral" version minimized the potential negative consequences of bST adoption and portrayed bST as a safe and benign technology. The "negative" version emphasized the more controversial aspects of the technology and was designed to leave lingering concerns about the safety of bST. The remainder of the questionnaire probed attitudes toward bST, elicited milk consumption response contingent on the introduction of bST, and obtained demographic information from the respondents. The cover letter accompanying the survey requested that the main grocery shopper in the household complete the survey.

The sampling frame consisted of households with Virginia mailing addresses, from which a random sample of 2,100 names and addresses was drawn. The survey instrument was field tested with an initial mailing in September 1989 to a random sub-sample of 100 households. Based on returns from the field trial, the survey instrument was modified slightly and mailed in October 1989 to the remaining 2,000 households in the sample. Responses from the field trial and the general mailing were pooled together because differences in the survey instruments were negligible and no significant differences in the distributions of responses could be found. A total of 605 usable questionnaires including those from the field trial were returned, resulting in a response rate of just over 32 percent. (The overall sample size was reduced to 1,870 households because 230 mailings were returned as undeliverable.)

To assess whether the sample is representative of all *households* in Virginia, characteristics of households in the sample can be compared with those of households in Virginia (Table 1). The sample nearly matched the state population with respect to place of residence, with about two-thirds urban and one-third rural households. Also, the average number of persons per household in the sample was only one-tenth of a person greater than the average of 2.63 for the state. In contrast, fewer than 16 percent of the respondents reported household incomes below $20,000, but nearly 57 percent of Virginia households belong in that bracket. At the other end of the income spectrum, two-thirds of the households in the sample had incomes of more than $30,000 compared to less than one-fourth of all households in Virginia. Consequently, the sample is biased in that it overrepresents wealthier Virginia households.

A weighting procedure, or poststratification, can be applied to reduce sample bias and hence increase sample representativeness. Thus, a scheme was developed to weight observations in each household

Table 1. Demgraphic Characteristics of Survey Sample Versus Virginia Population

Item	Survey Respondents	State
	- - Percent - -	
HOUSEHOLD CHARACTERISTICS:		
Residence of Household		
Urban	64.2	67.5
Rural	35.8	32.4
Number of Persons Per Household	2.73	2.63
Income of Households		
Less than $10,000	5.5	26.6
$10,000-$19,999	11.0	30.2
$20,000-$29,999	16.5	20.6
$30,000-$49,999	32.7	17.6
$50,000+	34.2	5.0
INDIVIDUAL CHARACTERISTICS:		
Age		
20-29 years of age	9.6	27.5
30-39 years of age	24.4	22.4
40-49 years of age	21.9	15.5
50-59 years of age	17.6	14.8
60-69 years of age	17.4	11.0
70+ years of age	9.0	8.6
Education of Persons 25+ Years of Age		
8th grade or less		
Some high school	2.5	22
Complete high school	4.7	16
Some college	18.0	28
Completed college	29.4	15
	45.0	19
Race		
Caucasian	92.3	80.1
Non-Caucasian	7.7	19.9

Sources: U.S. Bureau of the Census: Statistical Abstract of the U.S.; 1980 Census of Population, Characteristics of the Population: Virginia; and mailed survey of Virginia households.

[1]Copies of the survey instrument are available from the authors upon request.

[2]Changes in information presented to respondents have been shown to produce statistically significant differences in responses to questions in contingent valuation surveys (e.g. Cummings et al.; Bergstrom et al.). While not a focal point of this study, the two descriptions were generated to identify potential "information biases" resulting from subtly different presentations of essentially the same information.

income stratum. The weights equalled the proportion of households in the sampling frame (all households in Virginia) in each income stratum divided by the proportion of households in the sample in each stratum (see Cochran pp. 134-135). Use of the weighted observations is appropriate when projecting results to the population of Virginia households. The empirical analysis notes when the weighting procedure is applied.

Sample representativeness cannot be established by comparing demographic characteristics of the respondents to those of *all* individuals in Virginia, because the sampling unit was the main grocery shopper within the household. (A legitimate comparison requires statistics on characteristics of main grocery shoppers within Virginia households.) Nonetheless, comparisons are consistent with the earlier finding that the sample is not representative of households in Virginia. A comparison of individual demographic characteristics (Table 1) suggests that the survey respondents tended to be older and had completed more years of formal education relative to the adult population of Virginia. Further, racial minorities appear to be under-represented. To the extent that the weighting procedure also corrects for these (potential) biases, the weighted results may more nearly reflect responses from all Virginia residents.

BST AND THE DEMAND FOR FLUID MILK

To assess the impacts of the introduction of bST on potential changes in the demand for dairy products, respondents first were asked about current weekly household purchases of fluid milk. Respondents then were asked how their milk purchases would change following the introduction of bST, given three price scenarios: (1) milk prices remain at current levels, (2) prices drop by 10-cents per gallon, and (3) Prices drop by 40-cents per gallon. Table 2 presents the distributions of both the weighted and unweighted responses to the three price scenarios. The weighted or poststratified responses correct for sampling bias across household income, as described above, and thus represent a more valid generalization of the distributions of responses for Virginia households. Hence, the following discussion focuses on analysis of the weighted responses.

Given the assumption that bST is introduced and the price of milk remains the same, the weighted distribution shows that almost 15 percent of households will reduce their weekly purchases of fluid milk. Of these households, almost two-thirds will stop buying milk altogether. These results show a considerably smaller negative consumption response compared to other studies, which found no less than one-third of respondents expressing intentions to reduce purchases if bST (or an unspecified hormone) is introduced (Douthitt; Henderson; Slusher; Smith). Unless each person or household intends to reduce milk purchases by exactly the same amount, however, such information does not allow the potential shift in demand to be quantified.

Interestingly, Virginia respondents stating that their consumption of milk will *decrease* following the introduction of bST have greater current average household milk consumption compared to respondents reporting *no decrease* following the introduction of bST (2.10 versus 1.41 gallons/week). Given the responses for which complete information was available (533 respondents), total weekly household consumption of fluid milk at current prices is pre-

Table 2. Impact of bST on Fluid Milk Consumption

bST Introduced and Price/Gallon:	Weekly Fluid Milk Consumption Will:							
	Increase Substantially	Increase Slightly	Remain Unchanged	Decrease Slightly	Decrease Substantially	Stop	Don't Know	n
	percent							number
Unchanged	0.0[a]	1.5	82.7	2.3	3.1	9.5	1.0	558
	(0.0)	(0.7)	(81.6)	(3.7)	(4.7)	(7.4)	(1.9)	(593)
Decreases 10 cents	2.0	4.0	77.2	3.9	3.0	9.5	0.5	560
	(0.5)	(3.0)	(79.0)	(3.9)	(4.2)	(7.7)	(1.7)	(595)
Decreases 40 cents	3.7	7.8	71.0	3.5	3.0	10.4	0.5	550
	(1.8)	(9.2)	(71.8)	(3.5)	(4.2)	(7.7)	(1.7)	(596)

[a]For each statement, the top row of numbers indicates the distribution of responses after weighting to correct for sample selection bias with respect to household income. The numbers in parentheses indicate the distribution of responses for the sample.

Source: Mailed survey of Virginia households.

dicted to decrease by 17.8 percent following the introduction of bST.[3]

Will a decrease in milk price help to offset reductions in milk consumption following the introduction of bST? Results reported in Table 2 suggest that price decreases will lead some households to increase milk consumption substantially, but the increases are not sufficient to overcome the aggregate decreases attributable to bST. The 17.8 percent potential reduction in fluid milk sales with no price change decreases to a 14.1 (± 5.5) percent reduction with a 10-cent per gallon decrease in price and to a 9.2 (± 6.6) percent reduction with a 40-cent per gallon decrease in price.[4]

For those respondents indicating that they will reduce their milk consumption following the introduction of bST, there is a potential trade-off with lower prices. Thus, under the assumption that bST is introduced, the average household consumption of milk at current prices for these households was compared to average consumption, assuming that prices decrease by 10 and 40 cents per gallon. Based on t-tests, no significant changes in consumption were found. Given the large changes in prices considered (approximately 5 percent and 20 percent decreases from current prices), this finding suggests that consumers are not willing to trade off price versus acceptance of bST technology. That is, those consumers who will reduce milk consumption because of the presence of bST will not subsequently be induced to increase consumption if prices drop. Conversely, some of the majority whose milk consumption will not be influenced directly by the introduction of bST will indeed respond to lower prices with increased purchases.

To address important demand and marketing implications, a regression model was used to determine whether demographic characteristics explain consumers' reactions to the introduction of bST. A binary variable (DECREASE) was constructed to indicate whether or not the respondent planned to decrease or even stop consumption of milk. This variable was then regressed on demographic and control variables using a logit framework.[5] The demographic variables include intercept shifters indicating whether the respondent lives in a rural area (RURAL); is female (FEMALE); is caucasian (CAUCASIAN); has completed high school, some college, or college (SCHOOL); and lives in a household with income between $10,000 and $19,999, between $20,000 and $29,999, between $30,000 and $49,999, or greater than $50,000 (INCOME). Also included are two continuous variables indicating the age of the respondent (AGE) and the number of children in the household under 12 years of age (CHILDREN).[6] Two intercept shifters are included to control for d

Rather than the coefficients, the implied marginal probabilities of the model are presented in Table 3.[7] Table 3 also shows the significance of each of the independent variables (based on t-tests or chi-square tests on the original coefficients) and several goodness-of-fit measures for the model. In addition to the familiar significance levels for testing single hypotheses, the table shows significance levels adjusted to account for the 10 hypotheses that are tested simultaneously when the significance of *each* demographic characteristic and control variable is assessed (Savin).[8]

Only the coefficients on the variables HEARD and CONSUMPTION are significantly different from

[3]The 95 percent confidence interval obtained using the sample standard error of the absolute changes is 17.8 ± 4.9 percent. The 95 percent confidence interval for the unweighted data is 14.2 ± 4.2 percent.

[4]The corresponding 95 percent confidence intervals for the unweighted data show reductions of 12.7 (æ 4.3) percent and 9.1 (± 4.8) percent for price decreases of 10 and 40 cents per gallon, respectively.

[5]Initially, a linear regression model ($y = X\beta + a$) was estimated using least squares. Misspecification tests indicated that all of the usual assumptions were valid with the exception of the assumption that the conditional distribution ($y \mid X$) is normal (as would be expected given categorical data). As an alternative ($y \mid X$) is assumed to be distributed binomial, so a logistic functional form is used to ensure that the estimated probabilities lie in the interval [0, 1] and that the estimated probabilities always sum to one.

[6]As shown in Table 1, AGE is a categorical response variable. Simply numbering the categories in order allows the variable to be treated as sontinuous. Entering AGE as a categorical variable neither improved measures of goodness-of-fit, nor altered the signs and significance of the coefficients on the independent variables.

[7]See Maddala for the formulas used to calculate the marginal probabilities.

[8]If one wishes to maintain a constant level of significance when testing several hypotheses simultaneously, some adjustment of the "usual" critical value for each test is necessary. For example, when using a 10 percent level of significance and the usual critical t-values to perform 10 individual t-tests in a single equation, one expects to reject incorrectly *one* true hypothesis. If the goal is to maintain a 10 percent probability of rejecting incorrectly a true hypothesis, the level of significance (and thus, critical value) used to test the individual hypotheses must be adjusted. A Bonferroni test provides one of several possible methods of adjusting the significance level. If an overall or "nominal" level of significance, say, 10 percent is to be maintained when conducting tests of 10 hypotheses, the significance level at which each individual hypothesis should be tested is 0.10 divided by 10 (the number of hypotheses). Thus, to maintain an overall level of significance of 10 percent, the level of significance for testing the individual hypotheses must be 0.01 (= 0.10 / 10).

Table 3. Socioeconomic Determinants of Changes in Milk Consumption Contingent on the Introduction of bST

X	Marginal Probabilities[a] ∂P(DECREASE)/∂X	Asymptotic[b] t-statistic	Significance Level[c]	Adjusted Significance Level[d]
RURAL	0.043	-1.48 (530)	.139	1.000
FEMALE	0.021	-.73 (530)	.466	1.000
CAUCASIAN	0.022	.37 (530)	.712	1.000
AGE	-0.006	.58 (530)	.564	1.000
CHILDREN	0.004	-.26 (530)	.793	1.000
SCHOOL		.57 (3)[e]	1.000	1.000
HIGH	-0.017			
SCOLLEGE	-0.017			
GRAD	-0.029			
INCOME		.60 (4)[e]	1.000	1.000
I10-20	-0.030			
I20-30	-0.030			
I30-50	-0.003			
IG50	-0.008			
HEARD	0.107	-3.61 (530)	.000	.001
FORM	-0.009	.36 (530)	.721	1.00
CONSUMPTION	0.029	-2.57 (530)	.010	.100

Overall MODEL (n=546): $\chi^2(15) = 31.9$ (p=.007)
Maddala's Pseudo R-square: .05
Percent Correctly Predicted: 86.08

[a]The marginal probabilities indicate the change in the probability that a respondent will decrease fluid milk consumption (price unchanged) given a change in each independent variable.

[b]Degrees of freedom are in parentheses. These t-statistics are those associated with the underlying coefficients of the logit model.

[c]Traditional level at which effect would be considered significant; assumes conducting single hypothesis test.

[d]The adjusted significance levels can be viewed as the nominal significance level at which each effect can be considered significantly different from 0 using a Bonferroni test ot adjust for multiple (10) hypotheses.

[e]Chi-squared test statistic.

zero at a (nominal) significance level of 10 percent. Results show that having heard of bST prior to receiving the survey, and having higher levels of household milk consumption, increase the marginal probability that a respondent will reduce or eliminate milk purchases following the introduction of bST. Thus, the results suggest that prior information about bST was interpreted negatively. Results for the consumption variable are logical in the sense that those with higher levels of consumption are more likely to decrease milk consumption following the introduction of bST if such decisions are predicated on human food safety concerns. This inference and the lack of significance of the coefficients on the demographic variables suggest the need to explore further how the respondents perceived particular issues associated with bST. Also, there is a need to determine which particular concerns, if any, influence the decision to decrease or eliminate milk purchase if bST is approved.

ATTITUDES REGARDING BST

Respondents were asked to indicate agreement or disagreement with a series of statements regarding the impact of the introduction of bST on the safety of milk, the price of milk, farmers going out of business, and the well-being of cows. In addition, responses were obtained to statements about labelling milk from bST-treated cows, confidence in the government ensuring the safety of milk, and about general shopping behavior regarding food safety. Possible responses were:Agree, Tend to Agree, Tend

to Disagree, Disagree, or Don't Know. The analysis consolidates the category Agree with Tend to Agree and the category Tend to Disagree with Disagree. Although the disaggregated data provide marginally more information, consolidating four of the five possible responses into two categories aids in the exposition without altering the basic conclusions.

Although Table 4 presents the distributions of both the unweighted and weighted responses for each question probing consumer attitudes, the following discussion focuses on analysis of the weighted responses. It is interesting to note, however, how the weighting scheme affected the distributions of responses. Namely, weighting increased the percentage of responses in the Don't Know category for each question. The unweighted responses thus indicate greater surety about attitudes compared to responses that are poststratified to represent more accurately the population of consumers in Virginia.

Despite research evidence that the human safety of milk is not affected by treating cows with bST, the weighted distribution of responses shows that nearly 21 percent of Virginia consumers disagreed or tended to disagree that such milk would be safe to drink, and almost 44 percent were not sure. In comparison, surveys conducted in both Missouri (Slusher) and Wisconsin (Douthitt) showed that more than 70 percent of consumers in those states expressed concern about the safety of milk from cows treated with bST. In addition to differences in survey instruments, the comparatively lower levels of concern about milk safety among Virginia consumers may be attributable to less exposure to media coverage of issues surrounding bST. Only 20 percent of the Virginia respondents had heard of bST prior to receiving the mail survey. More than 40 percent of the Missouri respondents and nearly 90 percent of the Wisconsin respondents had heard about bST prior to being surveyed. The difference in results suggests that media reports about bST have increased consumer uneasiness about its safety for use in food production.

One-fourth of the respondents disagreed or tended to disagree that the government will make sure that milk supplies are safe and wholesome. Hence, many consumers may need more than government assurances before they are convinced of the safety of milk from cows administered supplemental bST. More than 70 percent of Virginia consumers claimed to avoid buying certain foods because of safety concerns. Over 85 percent agreed or tended to agree that milk from bST-treated cows should be labelled. Other surveys showed similarly high levels of agreement that milk from treated cows should be labelled (Douthitt, Henderson, Slusher). Mandatory labelling may steer consumers away from milk produced by cows treated with supplemental bST, given that a

Table 4. Virginia Consumers' Attitudes about bST

Statement	Agree/ Tend to Agree	Disagree/ Tend to Disagree	Don't Know	n
	Percent			number
Approval of bST will make milk unSAFE to drink	20.7[a] (18.7)	35.6 (44.1)	43.7 (37.2)	575 (599)
The GOVERNMENT will make sure that milk supplies are safe and wholesome	58.1 (54.4)	24.6 (33.8)	17.2 (11.7)	573 (597)
The approval of bST will be beneficial if it lowers the PRICE of milk	42.4 (44.7)	37.3 (42.9)	20.3 (12.4)	573 (595)
I avoid BUYing certain foods because I am concerned about whether they are safe	73.1 (79.2)	19.3 (18.2)	7.6 (2.7)	577 (600)
I am concerned that INJECTing bST into cows is inhumane	37.9 (34.0)	39.7 (52.0)	22.4 (14.0)	576 (600)
I am concerned that bST may cause farmers to go out of BUSINESS	38.1 (36.3)	36.9 (44.1)	25.1 (19.6)	579 (603)
Milk from bST-treated cows should be LABELed	85.8 (85.4)	6.2 (8.8)	8.0 (5.8)	578 (601)
bST should be approved	44.1 (43.3)	21.9 (24.5)	33.7 (32.1)	581 (600)

[a]For each statement, the top row of numbers indicates the distribution of responses after weighting to correct for sample selection bias with respect to household income. The numbers in parentheses indicate the distribution of responses for the sample.

Source: Mailed survey of Virginia households.

large majority of consumers claimed to avoid some foods because of safety concerns.

Compared to the other issues, the statement that the "approval of bST will be beneficial if it lowers the price of milk" elicited a more evenly split response. Forty-two percent of consumers agreed or tended to agree with the statement, while 37 percent tended to disagree or disagreed. Only 38 percent expressed concern that bST may cause farmers to go out of business, and one-fourth of consumers were undecided about this issue (perhaps because they were not sure if farmers would indeed go out of business). Given the high media profile of animal rights issues in recent times, a surprisingly low 38 percent of consumers expressed concern that injecting cows with bST would be inhumane.

In addition to statements about these individual issues regarding bST, consumers were asked to respond to the statement that bST should be approved. A plurality, but not a majority, of consumers agreed or tended to agree that bST should be approved. Slightly more than one in five consumers objected to approval, with one-third not sure.

As was alluded to in the previous section, a respondent's attitudes toward individual issues may be expected to influence the decision to reduce or eliminate purchases of milk if bST is approved for commercial use. Thus, a logit model was estimated to explain the binary variable DECREASE as a function of intercept shifters indicating whether the respondent reacted negatively or positively to each of the issues (SAFE, PRICE, BUSINESS, GOVERNMENT, and INJECT).[9] To illustrate construction of the independent variables, the intercept shifter Worried (Not Worried) associated with SAFE assumes a value of one if the respondent indicated concern (no

Table 5. Issues Explaining Changes in Milk Consumption Contingent on the Introduction of bST

X	Marginal Probabilities[a] $\frac{\partial P(DECREASE)}{\partial X}$	χ^2 Test-Statistic[b]	Significance Level[c]	Adjusted Significance Level[d]
SAFE		10.62(2)	.005	.035
Not Worried	-.04			
Worried	.03			
PRICE		19.65(2)	.000	.000
Not Important	.08			
Important	-.03			
BUSINESS		4.90(2)	.084	.588
Not Worried	-.001			
Worried	.04			
GOVERNMENT		18.20(2)	.000	.000
Not Trust	.01			
Trust	-.08			
INJECT		3.60(2)	.165	1.00
Not Worried	.02			
Worried	.05			
HEARD	.06	3.05[e]	.002	.014
FORM	.02	1.21[e]	.228	1.00

Overall model (n=576): $\chi^2(12) = 134.18$(p = .000)
Maddala's Pseudo R-square: .21
Percent correctly predicted: 85.93

[a]The marginal probabilities indicate the change in the probability a respondent will decrease fluid milk consumption (price unchanged) given a change in each independent variable.

[b]Degrees of freedom are in parentheses. These test-statistics are those associated with the underlying coefficients of the logit model.

[c]Traditional level at which effect would be considered significant; assumes conducting single hypothesis test.

[d]The adjusted significance levels can be viewed as the nominal significance level at which each effect (issue) can be considered significantly different from 0 using a Bonferroni test to adjust for multiple (7) hypotheses.

[e]Asymptotic t-statistic.

[9]The underlined word in each statement in Table 4 indicates the name used to identify the issue central to that particular statement. BUY and LABEL are omitted from the equation because of collinearity problems with the intercept, as more than three-fourths of those responding agreed or tended to agree with these statements. The issue variables are not treated as ordered variables because there is no logical sequence for the possible responses.

concern) about the safety of milk from bST-treated cows. Both of the intercept shifters Worried and Not Worried equal zero for Don't Know responses.

The results shown in Table 5 indicate that BUSINESS, INJECT, and FORM are not important determinants of the respondent's decision to buy less milk if bST is approved. Conversely, the results indicate that the coefficients on the variables associated with SAFE, PRICE, GOVERNMENT, and HEARD are all significant at a (nominal) significance level of 10 percent. Moreover, the signs of the implied marginal probabilities conform to expectations. The marginal probabilities show the change in the probability of decreasing milk purchases after bST is introduced, given that the respondent is, for instance, worried or not worried rather than undecided about a particular issue.

Specific marginal probabilities indicate that, relative to being undecided about the safety of milk from cows treated with bST, not being worried reduces the probability of decreasing milk purchases following the introduction of bST. Respondents worried about milk safety are *more* likely to decrease milk purchases than are those who are undecided. In comparison to the base "undecided" group, the other large marginal probabilities indicate that those who think that a decrease in the price of milk is not important are *more* likely to decrease milk purchases, those who trust the government are *less* likely to decrease purchases, and those who have heard about bST are *more* likely to decrease milk purchases contingent on the introduction of bST.

DETERMINANTS OF ATTITUDES ABOUT BST

The analysis above highlights the particular issues associated with decreases in milk consumption following the introduction of bST. To identify potential target groups for educational or marketing campaigns, a multinomial logit framework was utilized to determine the extent to which demographic characteristics and available information explain the concerns of consumers. The dependent variables are the (unweighted) measures of respondents' attitudes toward issues surrounding the approval of bST, as shown in Table 4. Because there is no obvious sequence for the three categories Agree/Tend to Agree, Tend to Disagree/Disagree, or Don't Know, multinominal rather than ordered logit is the appropriate analytical tool. Except for CONSUMPTION, the independent variables are the same demographic and information control variables included in the model shown in Table 3.

Table 6 reports several measures of the overall fit of the estimated equations and the implied marginal probabilities. The significance level for each variable is adjusted to maintain a constant overall level of significance given that nine hypotheses are tested simultaneously.[10] The results indicate that the estimated equations explain a relatively small part of the variability of the dependent variables, as shown by the range of 9 to 14 percent for Maddala's pseudo R-square measure. The percentage of correct predictions ranges from 52 to 58 percent. Based on the overall chi-square statistic for each regression, all models are significant at the 0.01 level.

Coefficients on several variables are different from zero at the 0.10 level of significance in each of the regressions even after adjustment of significance levels for testing nine hypotheses simultaneously. Results for the SAFE equation indicate that gender and income are significant determinants of consumers' levels of concern about the safety of milk from cows treated with supplemental bST. Implied probability changes show that females rather than males are *more* likely to worry that such milk is unsafe, while respondents with incomes greater than $50,000 are *less* likely to worry. Compared to those in all other income categories, respondents whose household income is in the $20,000-$49,999 dollar range are most likely to worry about the safety of milk from bST-treated cows.

Significant coefficients indicate that females and those having heard of bST prior to the survey are more likely to dispute the statement that "bST will be beneficial if it lowers the price of milk" (PRICE). Similarly, as might be expected, progressively higher household income raises the probability of a respondent disagreeing that bST would be beneficial simply because it may lower the price of milk.

The significant variables explaining whether respondents are worried that bST may cause farmers to go out of business (BUSINESS) indicate greater concern by females and those who had heard about bST prior to the survey. The income intercept shifters are also significantly different from zero. Marginal probabilities for the income variables suggest that respondents from the highest income households are the most likely to state that they are *not* worried about bST adoption driving farmers out of business.

Respondents most worried about the cruelty of bST injections (INJECT) include females and con-

[10]Namely, tests are performed on the effects of place of residence, gender, race, age, number of children under 12, schooling, income, whether bST had been heard of prior to the survey, and form of bST description. The effect of schooling (income) is tested by omitting all schooling (income) intercept shifters.

Table 6. Socioeconomic Determinants of Attitudes Toward Issues Regarding the Introduction of bST: Safety and Price

X	SAFEY		PRICE		BUSINESS		INJECT		GOVERNMENT	
	Marginal Probabilities[a]		Marginal Probabilities[a]		Marginal Probabilities[a]		Marginal Probabilities[a]		Marginal Probabilities[a]	
	∂P(Not Worried)/∂X	∂P (Worried)/∂X	∂P (Beneficial)/∂X	∂P(Not Beneficial)/∂X	∂P(Not Worried)/∂X	∂P (Worried)/∂X	∂P(Not Worried)/∂X	∂P (Worried)/∂X	∂P (Trust)/∂X	∂P (Don't Trust)/∂X
RURAL	-0.0244	-0.0021	-0.0349	0.0145	-0.0650	-0.0023	-0.1354[b]	0.0940[b]	-0.0715	0.0397
FEMALE[b,c]	-0.1305	0.0653	-0.1753	0.1688	-0.1982	0.0966	-0.2337	0.1928	-0.0590	-0.0184
CAUCASIAN	-0.0900	-0.0164	-0.1613	0.0801	0.0380	0.0307	-0.0108	0.0188	-0.2123[b]	0.1902[b]
AGE	-0.0309[b]	-0.0066[b]	0.0190	-0.0224	0.0344[b]	-0.0450[b]	0.0122[b,c]	-0.0406[b,c]	0.0034[b,c]	-0.0262[b,c]
CHILDREN	-0.0231	0.0145	0.0123	-0.0099	0.0252	-0.0088	0.0212	-0.0323	0.0130	-0.0042
SCHOOL										
HIGH	-0.0159	-0.0055	0.0270	0.0025	0.0017	0.0280	-0.0588[b]	-0.0337[b]	0.1594[b,c]	-0.1482[b,c]
SCOLLEGE	-0.0631	0.0332	0.0069	-0.0480	0.0162	0.0271	0.0133[b]	-0.0503[b]	0.0209[b,c]	0.0068[b,c]
GRAD	0.0749	0.0084	0.0169	-0.0431	-0.0032	0.0173	0.0541[b]	-0.0738[b]	0.0956[b,c]	0.0027[b,c]
INCOME[b,c]										
I10-20	-0.0284	-0.0522	-0.0499	0.0411	-0.0303	0.0363	-0.0457	0.0470	0.0503	-0.1484
I20-30	-0.0194	0.0357	-0.0202	0.0678	-0.0064	0.0652	-0.0922	0.1060	0.0318	-0.0309
I30-50	0.0650	0.0291	-0.0147	0.0771	-0.0086	0.0333	-0.0240	0.0933	-0.0470	0.0857
IG50	0.0856	-0.1132	-0.0054	0.1109	0.0311	0.0386	0.0535	0.0159	-0.0414	0.0608
HEARD	-0.0003	0.0327	-0.1766[b,c]	0.1815[b,c]	-0.1594[b,c]	0.1563[b,c]	0.0026	0.0018	-0.0427	0.0132
FORM[b]	0.1001	-0.0651	0.0765	-0.0943	-0.1051	0.0997	0.0093	0.0348	0.0537	-0.0909
	Overall Model (n=557): $\chi^2(28)=56.2$ (p=.001) Maddala's Pseudo R-square: .096 Percent Correctly Predicted: 51.89		Overall Model (n=557): $\chi^2(28)=52.79$ (p=.003) Maddala's Pseudo R-square: .090 Percent Correctly Predicted: 52.42		Overall Model (n=557): $\chi^2(28)=56.2$ (p=.000) Maddala's Pseudo R-square: .103 Percent Correctly Predicted: 51.89		Overall Model (n=557): $\chi^2(28)=80.49$ (p=.000) Maddala's Pseudo R-square: .135 Percent Correctly Predicted: 57.63		Overall Model (n=557): $\chi^2(28)=66.19$ (p=.000) Maddala's Pseudo R-square: .112 Percent Correctly Predicted: 57.81	

[a]The marginal probabilities indicate the change in the probability that a respondent will agree/tend to agree or tend to disagree/disagree with the particular issue. The change in the probability that the respondent "does not know" is equal to -(∂P(Not Worried/Beneficial/Trust)/∂X + ∂P(Worried/Not Beneficial/Don't Trust)/∂X).

[b]Tests based on the underlying coefficients in the multinominal logit model are significant at a 10 percent level using usual (χ^2) critical values.

[c]Tests based on the underlying coefficients in the multinominal logit model are significant at a 10 percent level using a Bonferroni test to adjust for multiple (9) hypotheses.

sumers from households reporting income between $20,000 and $49,999. Also, the significant coefficients on the variable AGE show that the probability of stating concern about the cruelty of injections decreases with the respondent's age.

Older consumers are less likely to disagree that the government will make sure that milk supplies are safe and wholesome (GOVERNMENT). The significant coefficients on the gender intercept shifter indicate that compared to their male counterparts, females are more likely to be undecided whether the government will ensure that milk supplies are safe. High school graduation or higher schooling increases the probability of trusting that the government will protect the integrity of the milk supply. Respondents with incomes between $10,000 and $29,999 are more likely than those with lower incomes to trust the government, but those with incomes of $30,000 or higher are less likely to do so.

IMPLICATIONS

The findings of this research suggest that the introduction of bST for commercial milk production portends sizable negative consequences for fluid milk consumption. Of the 605 respondents to a questionnaire received by 1,870 randomly selected households in Virginia, nearly one-fourth did not think that bST should be approved for commercial use. Moreover, fluid milk demand is predicted to fall by as much as 17 percent as a result of decisions by consumers to reduce or eliminate fluid milk purchases if bST is approved. Attempts to explain the probability that a household will decrease or eliminate consumption of milk following the introduction of bST failed to identify any demographic characteristics (of the household and individual) as significant explanatory variables. Attitudes toward particular issues, however, were found to be significant predictors of the contingent consumption responses. Several demographic characteristics subsequently were identified as important determinants of consumers' attitudes about these specific issues. Interestingly, the effects of the demographic characteristics varied across the issues.

The research findings provide insight into potential strategies for introducing bST to consumers. Assuming that bST will receive final FDA approval, three approaches to consumer demand and acceptance can be taken. One approach is to do nothing, leaving the dairy industry vulnerable to a consumer backlash if farmers adopt bST. This is a risky and potentially dangerous option. The other two approaches are proactive in that they directly address the consumer issues. First, there appear to be good educational opportunities to attenuate negative consumer reaction to bST while its approval is still pending. Alternatively, a marketing strategy can be devised to accommodate rather than alter consumers' preferences.[11]

With respect to the consumer education approach, one-third of Virginia households are undecided about whether bST should be approved. Hence, a sizable percentage of the population could be swayed toward or against acceptance of bST. The research results provide guidance on the types of issues that educational materials should address. Issues of direct consequence to consumers play the largest role in formulating individuals' overall reactions to bST. Consequently, educational strategies should focus on issues such as the impacts of bST use on the safety of milk supplies and on milk prices. Confidence in the government's ability to ensure a safe milk supply is also a significant determinant of consumers' decisions to decrease or eliminate milk consumption following the introduction of bST. Broader social consequences of bST adoption, such as dairy farm survival, have less influence in consumers' potential reactions to bST.

Demographic targeting of groups for educational (or marketing) campaigns is a more difficult proposition. The results show that females tend to be more concerned about potential negative consequences of bST on a number of issues, although these concerns apparently do not translate directly into significantly greater likelihood of reducing milk purchases upon approval of bST. Income is also found to be a significant determinant of consumers' attitudes toward issues surrounding the introduction of bST. The influence of household income, however, is not a predictable linear association and its impact varies from issue to issue. Age and schooling also play a role in explaining consumers' attitudes on some issues.

Rather than attempting to change consumers' preferences, the marketing strategy option would attempt to minimize demand disruptions by serving the needs of the minority of consumers who would react negatively to the introduction of bST. The primary avenues of procurement, processing, and distribution for milk could remain as they are and include milk from any source, whether or not the cows have been treated with supplemental bST. Presumably, such milk would obtain a lower price than would be the case if bST would not be available.

[11] We are indebted to an anonymous reviewer for suggesting this approach.

For the one out of five households for which bST is objectionable, a second channel of distribution could be developed. A certification program could be implemented for marketing of milk from cows that have not been treated with bST. Retail packaging could include a label of certification, similar to the types of labelling now in use for organic food products. Such certified milk likely would cost more because of higher production costs at the farm level and because of added costs of processing and handling the milk. Although a single dairy processing plant may find it difficult to prevent commingling of milk from both certified and uncertified herds, it may be feasible for entire plants to be devoted to processing of certified milk only. According to estimates for 1970-1980, a fluid milk product manufacturing plant would require only 0.40 percent of industry shipments to achieve minimum efficient scale (Connor et al., p. 154). If consumers with objections to the use of bST represent 17.8 percent of fluid milk demand, then the industry may be able to support about 44 "certified" plants operating at minimum efficient scale. Even though processing costs may achieve minimum levels, costs for certified milk would still be inflated by larger raw milk procurement areas (unless all of the farmers in a plant's milkshed choose to become certified). Distribution costs likely would be higher as well. Nonetheless, it may be feasible to permit consumers to choose whether or not to pay a premium for certified milk rather than simply thrusting a new production technology upon them.

APPENDIX

Descriptions of Bovine Somatotropin Technology

Neutral Version:

MORE MILK THROUGH BIOTECHNOLOGY?

Bovine somatotropin (BST) is a hormone that is produced naturally in dairy cows. Advances in biotechnology have made it possible to produce BST in the laboratory. University research over the past 7 years shows that diary cows injected with BST produce 10 to 25% more milk. BST should lower the farmer's cost of producing milk. It should improve incomes on dairy farms. As a result, the price of milk could decrease as much as 10 cents a gallon. BST cannot be added to the cow's feed. It must be given by injection. The frequency of these injections may range from once a day to once every 14 to 28 days.

There is some opposition to the use of BST. The main concerns are that BST will create milk surpluses, and that may cause some dairy farmers to go out of business if the price of milk goes down, that injections to cows are cruel, that the use of BST will affect the safety of milk, and that biotechnology should not be used to change current ways of producing milk.

Virginia Tech Extension specialists conclude that giving extra BST to cows does not affect the quality and safety of milk and is not a threat to humans. Somatotropin is produced by all animals, including humans. It is not a steroid hormone. Small amounts of BST are found naturally in milk. Research shows that the amount of BST in milk from treated cows does not differ from that found naturally. Thus, BST testing of milk cannot determine if milk is from BST-treated cows. BST has no effect on humans whether eaten or injected.

BST is still under development. The Food and Drug Administration (FDA) may approve BST for commercial use in dairy cattle next year.

Negative Version:

MORE MILK THROUGH BIOTECHNOLOGY?

Bovine somatotropin (BST) is a hormone that is produced naturally in dairy cows. Advances in biotechnology have made it possible to produce BST in the laboratory. University research over the past 7 years shows that dairy cows injected with BST produce 10 to 25% more milk. BST should lower the farmer's cost of producing milk. It should improve incomes on dairy farms. As a result, the price of milk could decrease as much as 10 cents a gallon. BST cannot be added to the cow's feed. It must be given by injection. The frequency of these injections may range from once a day to once every 14 to 28 days.

There is opposition to the use of BST. Some individuals believe that BST will create large milk surpluses. This could depress the price of milk and drive some farmers out of business. Some people oppose BST because they believe that genetic engineering is either dangerous or should not be used in food production. Other people oppose BST because they feel that BST injections to cows are cruel. Also, there is concern by some people that too little research has been conducted to assure the safety of milk and dairy products from cows treated with BST.

University researchers believe that BST treatments of cows, given in reasonable doses, do not affect the quality or safety of milk and are not a public health threat. The amount of BST in milk from treated cows has not been shown to differ from that found naturally in milk. There is no available method to test if milk is from BST-treated cows. In the future, more sensitive methods may show differences in the level of BST in milk from treated and untreated cows. BST is not a steroid hormone. Available research shows that BST appears to have no direct influence on milk composition.

BST is still under development. The Food and Drug Administration (FDA) may approve BST for commercial use in dairy cattle next year.

REFERENCES

Bauman, D. E., J. P. Eppard, M. J. DeGeeter, and G. M. Lanza. "Responses of High-Producing Dairy Cows to Long-Term Treatment with Pituitary Somatotropin and Recombinant Somatotropin." *J. Dairy Sci.*, 68 (1985): 1352-1362.

Bergstrom, J. C., J. R. Stoll, and A. Randall. "The Impact of Information on Environmental Commodity Valuation Decisions." *Am. J. Agr. Econ.*, 72 (1990): 614-621.

Blayney, D. P., and R. F. Fallert. *Biotechnology and Agriculture: Emergence of Bovine Somatotropin (bST).* Washington, D.C.: USDA ERS Commodity Economics Division, Staff Report AGES 9037, June 1990.

CAES Consultants (Wye) Ltd. *BST and the Consumer: An Overview of Perceptions and Practices.* Centre for European Agricultural Studies, Wye College, Ashfort, Kent, U.K., December 1989.

Cochran, W. G. *Sampling Techniques*, 3rd ed. New York: John Wiley & Sons, 1977.

Connor, J. M., R. T. Rogers, B. W. Marion, and W. F. Mueller. *The Food Manufacturing Industries: Structure, Strategies, Performance, and Policies.* Lexington, Mass.: Lexington Books, 1985.

Council for Agricultural Science and Technology. "CAST Comments on Bovine Somatotropin (bST)." CAST News Release, Ames, Iowa, September 1, 1989.

Craigmill, A. L. *The Approval Process For New Animal Drugs.* New Dairy Technologies Fact Sheet NDT-10, Office of Information and Publications, University of Maryland, 1988.

Cummings, R. G., D. S. Brookshire, and W. D. Schulze. *Valuing Environmental Goods: An Assessment of the Contingent Valuation Method.* Totowa, NJ: Rowan and Allenheld, 1986.

Douthitt, R. A. "Biotechnology and Consumer Choice in the Market Place: Should There Be Mandatory Product Labeling? A Case Study of Bovine Somatotropin and Wisconsin Dairy Products." Paper presented at the Second International Conference on Research in the Consumer Interest, Snowbird, Utah, August 9-11, 1990.

Epstein, S. S. "Potential Public Health Hazards of Biosynthetic Milk Hormones." *Int. J. Health Services*, 20 (1990): 73-84.

Fallert, R., T. McGuckin, C. Betts, and G. Bruner. *bST and the Dairy Industry: A National, Regional, and Farm-level Analysis.* Washington D.C.: USDA ERS CED, Agr. Econ. Rp. No. 579, October 1987.

Griliches, Z. "Hybrid Corn: An Exploration in the Economics of Technical Change." Econometrica, 25.4 (1957): 221-243.

Haidacher, R. C., J. R. Blaylock, and L. H. Myers. *Consumer Demand for Dairy Products.* Washington, D.C.: USDA ERS Commodity Economics Division, Agr. Econ. Rp. No. 586, March 1988.

Henderson, P. C. "Consumers Balk at bST." *Dairy Today*, November/December 1989, pp. 14-6.

Hoban, T. "Public Attitudes Toward Bovine Somatotropin (BST)." Summary of a presentation prepared for the 39th Annual Dairy Conference, Winston-Salem, North Carolina, February 27-28, 1990.

Juskevich, J. C., and C. G. Guyer. "Bovine Growth Hormone: Human Food Safety Evaluation." *Science*, 249 (1990): 875-884.

Kaiser, H. M., and L. W. Tauer. "Impact of Bovine Somatotropin on U.S. Dairy Markets Under Alternative Policy Options." *N. Cent. J. Agri. Econ.*, 11.1 (1989): 59-73.

Kaiser, H. M., C. W. Scherer, and D. M. Barbano. "Consumer Perceptions and Attitudes Towards Bovine Somatotropin." Working paper, Dep. Agr. Econ., Cornell University, Ithaca, NY. May, 1991.

Kalter, R. J., R. M. Milligan, W. Lesser, W. Magrath, L. Tauer, and D. E. Bauman. *Biotechnology and the Dairy Industry: Production Costs, Commercial Potential, and the Economic Impact of the Bovine Growth Hormone.* Dep. Agri. Econ., A.E. Res. Pap. 85-20,Cornell University (December 1985).

Kimball, M., and R. T. Rogers. *Biotechnology in Massachusetts: Impact of Bovine Growth Hormone on the Dairy Industry with Comments on the Whole-Herd Buyout Program.* Dep. Agriculture and Res. Econ., University of Massachusetts, Ext. Pap. Series #86-2, November 1986.

Kinnucan, H., U. Hatch, J. J. Molnar, and M. Venkateswaran. "Scale Neutrality of Bovine Somatotropin: Ex Ante Evidence from the Southeast." *So. J. Agri. Econ.*, 22.2 (1990): 1-12.

Kronfeld, D. S. "Biologic and Economic Risks Associated with Use of Bovine Somatotropins." *J. of Am. Vet. Med. Associ.*, 192: (1988) 1693-1696.

Kuchler, F., and J. McClelland. *Issues Raised by New Agricultural Technologies.* Washington, D.C.; USDA ERS RTD Agr. Econ. Rp. No. 608, April 1989.

Maddala, G. S. *Limited-Dependent and Qualitative Variables in Econometrics.* Cambridge: Cambridge University Press, 1983.

Marion, B. W., and R. L. Wills. "A Prospective Assessment of the Impacts of Bovine Somatotropin: A Case Study of Wisconsin." *Am. J. Agri. Econ.* 72.2 (1990): 326-336.

National Dairy Board. *Consumer Responses to the Introduction of bST Technology: Division a Communications Strategy—Final Report.* Chicago, Illinois (December 1986).

Savin, N. E. "Multiple Hypothesis Testing" *Handbook of Econometrics, Vol. 2,* Z. Griliches and M. D. Intriligator, eds. Amsterdam: North-Holland 1984.

Sellschopp, J., and R. J. Kalter. *Bovine Somatotropin: Its Impact on the Spatial Distribution of the U.S. Dairy Industry.* Dep. Agri. Econ., A.E. Research 89-14, Cornell University, September 1989.

Slusher, B. J. "Consumer Acceptance of Food Production Innovations—An Empirical Focus on Biotechnology and BST." Paper presented at the Second International Conference on Research in the Consumer Interest, Snowbird, Utah, August 9-11, 1990.

Smith, B. J. "Study Targets Consumer Reaction to bST Milk." *Hoard's Dairyman,* September 10, 1989, p. 686.

Smith, M. E., E. van Ravenswaay, and S. R. Thompson. "Sales Loss Determination in Food Contamination Incidents: An Application to Milk Bans in Hawaii." *Am. J. Agri. Econ.,* 70.3 (1988): 513-520.

U.S. Department of Agriculture *Dairy Situation and Outlook.* Washington, D.C.: CED ERS, DS-423, January 1990.

van Ravenswaay, E. O., and J. P. Hoehn. "The Impact of Health Risk on Food Demand: A Case Study of Alar and Apples." Department of Agricultural Economics Staff Paper No. 90-31, Michigan State University. Paper presented at the Economics of Food Safety Workshop, Alexandria, Virginia, June 4-6, 1990.

Zepeda, L. "Predicting Bovine Somatotropin Use by California Dairy Farmers." *West. J. Agr. Econ.* 15.1 (1990): 55-62.