rBST Use Among U.S. Dairy Farmers: A Comparative Analysis from 6 States

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I. Introduction

This paper uses data from dairy farmers in six U.S. states to examine farm-level factors influencing the adoption of recombinant bovine somatatropin (rBST), a productivity-enhancing hormone that is injected in cows. As a leading-edge agricultural biotechnology, rBST adoption has been studied extensively, in the eras preceding and following its commercial release in 1994 (see Barham; and Foltz and Chang; for entry points to the rBST adoption literature). To date, all of the empirical studies of rBST adoption determinants use data from a single state or even a region of a state to explore the issue at hand. Similarly, a companion literature on the profitability effects of rBST adoption, e.g. Foltz and Chang; Tauer and Knoblauch; Steffanides and Tauer; and Tauer, has only analyzed the issue using single state data. The absence of comparative multi-state work using similar methods and data raises questions about whether findings in the rBST adoption literature are specific to the locale, the econometric methods, or whether they are more general.

This paper's contribution is to provide a comparative analysis of rBST adoption using data from four major dairy producing states, Minnesota, New York, Texas, and Wisconsin and three minor ones, Connecticut, Idaho, and, Utah. These data were gathered as part of a U.S.D.A.-sponsored research project on the community impacts of structural change in dairy farming (NE-177). Two major themes of rBST adoption are explored in this paper. One concerns measures that indicate the degree to which the technology is likely to have broader effects on the performance of the dairy sector, namely the extent of adoption and disadoption across farms and the intensity of rBST use among current adopters. The other theme examines the determinants of rBST use to

identify what factors may be critical in shaping farmer adoption decisions and hence the future trajectory of this and other similar technologies. Combined, these two themes provide the basis for a current and prospective look at the underlying logic behind and the impacts of rBST adoption for the U.S. dairy sector.

The organization of the paper is as follows. The next section introduces the main empirical questions, describes the dataset, and specifies the econometric models deployed in the paper. Section 3 presents descriptive data on rBST adoption and disadoption as well as on the intensity of use on adopting farms. Three regional pools, one from the West, one from the Midwest, and one from the Northeast are formed, and data on characteristics of the farms in each state sample are shown to provide a solid basis for these pools. Section 4 provides the econometric results on the rBST adoption decision, distinguishing among current adopters, disadopters, and non-adopters in these regions. Section 5 develops the implications of the findings for our understanding of rBST adoption in the U.S. dairy industry.

2. Issues, Data, and Models

Prior to its commercial release, rBST was touted as a juggernaut technology, one whose introduction and rapid adoption was likely to transform the dairy sector through a major expansion of production, an ensuing decline in milk prices, and strong competitive pressure on farmers, especially those running smaller-scale operations (See for example: Lesser, Magrath, and Kalter; Marion and Wills; Zepeda, 1990; and for a more nuanced view: Larson and Kulcher). So far, rBST adoption appears to have fallen well short of the levels that would have been needed to make the technology a “juggernaut” (Barham,

Jackson-Smith, Moon, 2000), but, in fact, recent evidence on adoption levels remains rather scarce despite the plethora of papers on rBST adoption. In academic journals, statewide adoption figures have been reported recently only for Wisconsin (17%), Connecticut (32%), and California (25%).[1]

Data from Monsanto's web site, the sole commercial provider of rBST, provide national level estimates of about 13,000 U.S. dairy farmers currently using Posilac® on their herds (Monsanto, 2002). Compared to a U.S. total in 2001 of 97,500 dairy farms reported by the National Agricultural Statistical Service of USDA, this estimate would indicate a national farm-level adoption rate of around 13%, which seems low given the range of statewide estimates provided immediately above. This 13% adoption figure also seems low given that Monsanto also claims that "of the nearly 9 million dairy cows in the United States, approximately one-third are in herds supplemented with POSILAC." These two claims are internally consistent if the herd size on the average adopting farm is about 2.5 times the level of non-adopters, which is consistent with the literature's finding of a significant size bias in rBST adoption.

Adoption rates across farms are half of the "juggernaut or not" story. Adoption intensity on farm is the other, especially if one includes in that intensity measure farmers who have tried the technology but are currently not using it. Monsanto reports an average of 50% of cows being treated on farms currently using Posilac, but does not report at all on disadoption. The estimates available from Connecticut (Foltz and Chang), California (Butler, 1999), and Wisconsin (Barham, Jackson-Smith, and Moon; 2002) suggest that disadoption rates are substantial, ranging from 10% to 40% of farmers who

[1] Adoption figures for Wisconsin in 2001 are reported in Barham, Jackson-Smith, and Moon (2002). Adoption figures for Connecticut in 1999 are reported in Foltz and Chang. Adoption figures for California in 1997 are reported in Butler (1999).

have tried the technology. A better understanding of the extent of disadoption and the reasons for it is another critical piece of the rBST adoption story, and is further explored below.

As one benchmark for the potential impacts of rBST use in the dairy sector, we can combine Monsanto's estimate of the 50% intensity of Posilac use on currently adopting farms, with the estimated 3 million cows in herds where Posilac is being used. This would give a national figure of about 1.5 million out of 9 million dairy cows being treated with the technology, or about 17% of the cows nationally. Finally, if these cows are experiencing the 10% productivity boost commonly associated with rBST adoption (see e.g. Foltz and Chang), then the technology would account for about a 2% higher level of national milk production than would be obtained without its use. This 2% figure is significantly lower than *ex-ante* predictions found in the literature prior to rBST's introduction.

Estimates of adoption rates, disadoption, adoption intensity, and production differences are useful benchmarks to keep in mind in the ensuing discussion of rBST adoption. Just as important, however, is a sense of the main determinants of adoption and disadoption. Recent studies (using data from the Northeast or Wisconsin) have shown that both larger herd-size (or scale) and higher use of complementary (productivity-enhancing) technologies increase the likelihood that farmers will try rBST on their herds (Steffanides and Tauer; Foltz and Chang; Barham, Jackson-Smith and Moon, 2002). But, the question remains whether these outcomes hold across different locales, especially in the West where dairy herd sizes are typically much larger and more farmers use the complementary technology identified in the Northeast and Upper Midwest studies.

Traditional human capital variables, such as age and education levels, have also been found in some instances to be important in shaping rBST adoption decisions, with higher educated and younger farmers being more likely to adopt rBST than less educated and older farmers (Foltz and Chang).

Data and Methods:

The data used in this study come from a collection of cross-sectional surveys of populations of dairy farmers undertaken in select communities in seven states (see Appendix I for a description of the research sites).[2] The surveys were constructed in a manner that makes the responses readily comparable for questions regarding rBST and complementary technology use, farm structure, farm operator, and farm performance indicators. This allows the kind of multi-state analysis of rBST adoption, disadoption, and intensity of adoption as yet missing from the literature.

Three disadvantages of these data deserve mention. One is that only in Wisconsin and Connecticut are the data explicitly comparable to statewide samples.[3] Because the other samples are from individual counties within states where no comparable statewide data are available, they must be considered as case studies of adoption in those states. A second but less serious disadvantage is that these data do not include information on farmer attitudes toward or experience with agricultural biotechnology, which precludes any analysis of how regional differences in attitudes might affect adoption patterns. A

[2] The locales are as follows: Stearns County in Minnesota, Ontario County in New York, xy County in Utah, yz County in Idaho, XY County in Texas, and three dairy communities in distinctive regions of Wisconsin (Athens, Chilton, and Richland Center). The Connecticut data are a statewide sample, but with only 250 dairy farmers in the state it is comparable to a minor dairy-farming county in some of the major dairy production states.

[3] In Wisconsin, the data for the three communities can be compared with the statewide averages from a survey undertaken at the same time, while the sample for Connecticut is based on a statewide survey.

third disadvantage of these data is that they were gathered in different years, ranging from 1997 in Wisconsin to 2001 in Utah and Idaho. Thus, they do not offer a "parallel" snapshot of adoption trends. This issue is addressed again below in section 4.

A multinomial logit model of rBST adoption is estimated in this paper (Zepeda; Barham; Barham, Jackson-Smith, and Moon, 2002) in order to identify the determinants of three distinct adoption decisions, that of current adopters, disadopters, and non-adopters (those that have not tried the technology).[4] In order to highlight the decision of whether to try rBST (i.e. both adoption and disadoption) in comparison to those who have never used rBST, we chose the non-adopters as the benchmark category against which the coefficient estimates are compared. This paper presents only the full results for the models with non-adopters as a benchmark, although a set using current adopters as a benchmark were also run in order to better identify the differences between the current adopters and the disadopters.

One of the main challenges of using these data is the potential for heteroskedasticity that arises from pooling data from distinctive productive environments (Greene). The strategy we pursue here is to group states into three regional groupings, Northeast (Connecticut and New York), West (Utah and Idaho), and Upper Midwest (Minnesota and Wisconsin). As demonstrated below, these groupings beyond having a geographic and econometric logic also appear to group closely related states in terms of

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[4] The probabilities for the multinomial logit model are: $\Pr(Y_i = j) = \frac{e^{\beta_j' x_i}}{1 + \sum_{k=1}^{J} e^{\beta_k' x_i}}$ *for j=1,2,...J* and $\Pr(Y_i = 1) = \frac{1}{1 + \sum_{k=1}^{J} e^{\beta_k' x_i}}$ (Greene). The log likelihood function that is maximized is developed from them.

the means of some key explanatory variables. In other words, we run 3 regressions in each case, one for each pair of states and then compare the coefficient estimates.[5]

Comparative Levels of rBST Adoption, Disadoption, and Intensity of Use

Rates of rBST adoption vary substantially across the state samples. As shown in Table 1, the lowest adoption rate for rBST is in the Wisconsin sample, where 15 % of farmers are currently using rBST. By contrast, the highest adoption rate was 44% in the New York sample.[6] The other sample states have adoption rates that are bunched in the 27-32% range, well above that of Wisconsin and below that of New York.[7] Note also that all of the other state estimates except that of Wisconsin are at least double the 13% national figure estimated from the Monsanto public adoption data.

Rates of rBST disadoption are less variable than adoption rates. All but one of the state samples report that about 20-25% of farmers who have tried rBST on their herds have become disadopters. The one exception is the Minnesota sample which has a disadoption rate of more than 40% among those farmers who have tried rBST.[8] These high rates of disadoption suggest that rBST has proven not to be a profitable technology for many farmers who have attempted using it, and provide *prima facie* evidence to

[5] We also estimated the models with corrections for heteroskedasticity using the multinomial logit version of the Huber-White robust variance technique. These results produced the same inference on the models reported. Since it is not clear that this particular correction is the correct one, we prefer to report the uncorrected standard errors. Results available from the authors upon request.

[6] The New York data comes from Ontario county where farms are significantly larger than the state average.

[7] A comparison of this Wisconsin sample with a statewide survey from the same year (1997) reveals that the adoption rate for this Wisconsin sample was actually slightly higher than the statewide figure of 12% (Barham, Jackson-Smith, and Moon, 2000), and the same as the 15% figure that was recorded in a statewide survey in 1999. Thus, the lower adoption rate in the Wisconsin sample is not merely an artifact of the earlier date of this survey, and the other relatively early data point is in New York, which offers the other extreme of the adoption range across these six states.

[8] A statewide sample of Wisconsin in 2001 revealed a similar level of disadoption to that reported in Minnesota. So, in this case, the earlier snapshot in Wisconsin does understate the degree of rBST disadoption, and suggests that disadoption is a prevalent phenomenon for this particular technology.

support the related line of work on rBST profitability (e.g. Foltz and Chang; Stefanides and Tauer) that fails to find statistically significant positive impacts on profitability among adopters.

The intensity of rBST use, reported also in Table 1, is measured by determining the average percent of milk cows treated on farms using rBST. The average rates reported in the states under comparison vary from 41% in the Wisconsin sample to 58% in Connecticut, with the other state samples ranging between 48 and 53%. Most of these intensity figures are, in fact, quite close to the 50% level reported by Monsanto. Only Wisconsin's intensity seems low. Barham, Jackson-Smith, and Moon provides a potential explanation; reporting that in Wisconsin a number of farmers are using the technology primarily as a means to extend lactations of a few cows, rather than for productivity enhancement of their herd.

The ordering of the columns in Table 1 reflects the regional groupings used in the ensuing regression analysis, with Connecticut and New York in the Northeast, Idaho and Utah in the West, Texas in the South, and Minnesota and Wisconsin in the Upper Midwest. The data in Table 1 show strong regional differences when one compares the demographic characteristics, herd size and productivity measures, and technology use patterns across the state samples. For example in the Minnesota-Wisconsin pair, where the sample averages for herd size numbers, educational outcomes, and other technology use rates are quite close to one another, the numbers are considerably lower than the averages in the other state samples. For example, median herd sizes in the Minnesota and Wisconsin samples are, respectively, 57 and 50, with the next closest state being Connecticut with a median of 90. Similarly, use rates of TMR in the Minnesota and

Wisconsin samples are, respectively, 38 and 25 percent, with the next closest state samples being Utah and Connecticut with rates of more than 60 percent.

The Idaho and Utah samples have geographically close dairy counties and show large farm sizes and relatively high use of productivity enhancing technologies when compared to other state. They have quite similar distributions of education among operators, with relatively high rates of college participation and B.A. degrees or higher compared to other states. The only farm characteristic where there is notable variation between Utah and Idaho is in the average herd size of the farms, where Idaho farms are considerably larger on average. This larger size may reflect, in part, the more recent emergence of dairy farming in Idaho.

The southern representative, Texas, which has a fairly recently constituted dairy industry, most closely resembles the western pair of Idaho and Utah. Texas has the largest average herd size, the highest adoption of rBST, and the highest use of three-times-a-day milking. In addition, more Texas dairy farmers are in the two highest education categories than in any other state, although Idaho is a close second. For the technologies in which information is available, Texas has relatively high use of production records and TMR.

The Connecticut and New York samples present more differences between themselves than the other pairings, with the New York sample having nearly twice the average herd size of the Connecticut farms. Nonetheless, they have the highest two rolling herd averages and have similarly high uses of productivity enhancing technologies, with the New York sample being consistently higher. In addition since many Connecticut dairy farmers use the Cornell extension system for information on

dairy issues, the farms in this region share a common information base about technologies.

Determinants of rBST Adoption and Disadoption

In specifying the explanatory variables used to explain adoption and disadoption in the multinomial logit, we follow the literature cited above that has to varying degrees found age, education, use of production records, use of complementary technologies such as TMR, and herd size to be significant determinants of rBST adoption. Farmer education and age variables are included to capture traditional human capital attributes: younger better-educated farmers are hypothesized to be more likely to adopt rBST. Production records and total mixed ration equipment are viewed as complementary productivity-enhancing technologies that should make the adoption of rBST more advantageous. They are also "mature technologies" in the sense that they were available long before the introduction of rBST, such that their adoption is unlikely to be endogenous to the rBST decision of farmers. Herd size is included to assess whether the adoption of rBST is positively related to size, as previous studies have shown (Barham, Zepeda, Saha et al., Foltz and Chang). Missing from this specification is any measure of farmer attitudes that were found to be of significance in previous work by Barham using 1994-95 adoption data in Wisconsin and again, to a lesser extent, by Barham, Jackson-Smith, and Moon using 1994-2001 panel data from the same Wisconsin producers. State binary indicators are included to pick up some attitudinal differences across states, where regulatory and political environments can differ substantively, as well as differences in the years the surveys were conducted.

The results of the multinomial logit regressions are reported in Table 3. For the Northeast and Western pairs, the TMR variable was dropped from the specification. This choice was essential in the Northeast case, because of a singularity problem that arose with all disadopters being TMR adopters, and was done in the Western case because the coefficient estimate was insignificant. Exclusion of the TMR variable made for a cleaner comparison of these two pairs. The results for the Upper Midwest pair are reported both with and without TMR included as further explained below.

The strongest result across all 3 regions is that herd size is a strong, positive, and statistically significant predictor ($p<.01$) of being a current adopter of rBST. Disadopters, like adopters are also shown to have higher herd sizes than non-adopters. In the Northeast and Upper Midwest pairs, the coefficient estimate on herd size for disadopters is slightly smaller than that of the current adopters, but it is also positive and significant at the ($p<.01$) level. Only in the Western pair is the coefficient estimate on herd size for disadopters notably smaller than for adopters with a positive value and statistically significant only at the 90% confidence level.

The results on the complementary productivity-enhancing technologies are also quite consistent across the state samples. The use of herd-production records are in all cases also strongly and positively associated with rBST adoption, with both the magnitude and significance of that coefficient being the strongest in the Upper Midwest and weakest in the West. Herd records are not significantly associated with being a disadopter in the West and the Northeast, but are statistically significant in the Upper Midwest. This may be because lower average use rates of herd records among farms in

the Upper Midwest allow this to be a distinguishing characteristic, whereas in other areas the high use rate among all farmers masks the small differences.

As mentioned above, the use of TMR is only reported in Table 3 for the Upper Midwest, where it is also positive and statistically significant among current adopters and positive but not significant among disadopters. However, TMR use is also very strongly associated with rBST adoption in the Northeast. It was excluded from the regression because of its high use rate: in the Northeast all of the disadopters were TMR users as were virtually all of the rBST adopters. Thus, adoption of TMR in the Northeast was in essence a necessary but not sufficient condition for having tried rBST as a technology. In the Western pair, TMR use is quite widespread, and does not appear to be an important determinant of the rBST adoption decision.

The traditional human capital measures of age and education give the least consistent results across the 3 regional pairs. The coefficient estimate on education level was positively and statistically significant as a predictor of current rBST adoption in the Northeastern and Western regions but not in the Upper Midwest. Indeed, in the Upper Midwest, the only one of the human capital coefficient estimates that was significant was education among disadopters, which was positive and significant the 90% confidence level. Thus, education in the Upper Midwest was only a significant predictor of disadoption and not adoption. This result is also consistent with findings from Barham, Jackson-Smith, and Moon (2002) in their panel study of rBST adoption among Wisconsin dairy farmers. The only case where the coefficient estimate on age was a significant predictor ($p < .05$) was among current adopters in the Northeast, where younger farmers are more likely to be rBST users.

Of the state indicator variables, only the Wisconsin one was significant, with farmers there being much less likely to be either current adopters or disadopters relative to Minnesota farmers. Since this particular regional pairing had the widest range of years between the two samples, these significant differences may be due to timing or may be capturing different attitudes or extension systems. While we have not measured attitudes, the non-significance of the New York and Utah indicator variables provides some suggestion that if there are attitude differences they may not be state based.

Discussion

This work has set out to provide a broad view of the adoption patterns of rBST across some of the major dairy producing regions of the country. Across the state samples, the lowest adoption rate was about 16%, while the unweighted average adoption rate was twice that level at 32%. Both of these estimates are higher than the 13% national adoption estimate derived from Monsanto data, the sole provider of rBST, which suggests that the national adoption rate is probably significantly higher than 13%. The state samples also reveal relatively high disadoption rates among dairy farmers in all of the state samples, which is consistent with doubts raised by recent research in New York and Connecticut concerning the profitability impacts of rBST adoption.

The results of the multinomial logit estimations of rBST adoption and disadoption mostly confirm the evidence on key determinants found in individual state studies of rBST. Herd size, education, and complementary technologies all play positive and important roles in rBST adoption, although only the coefficient estimates on herd-size are significant and strong predictors of adoption in all of the regressions. In addition, these

regressions confirm evidence found in Foltz and Chang and Barham, Jackson-Smith, and Moon (2002) that the main determinants of current adopters and disadopters are quite similar, essentially making current adopters and disadopters statistically indistinguishable from one another. This similarity between adopters and disadopters is also consistent with recent work that finds no significant profitability impact associated rBST adoption. By contrast, the magnitudes of the coefficient estimates for adopters and disadoptes, especially on herd size, and the significantly smaller herd sizes among non-adopters, suggest that there are major differences in most state samples between adopters and non-adopters. Put differently, it would seem unlikely that many current non-adopters would be likely to become adopters without major changes occurring in either farm herd sizes or in key macro variables, such as milk prices and dairy policy.

The most striking aspect of this paper's results is that herd size is such a strong predictor of rBST adoption on dairy farms across states with very different average herd sizes. For example, in the Western pair, where the average herd size is as large as the largest herds in the Upper Midwest pair, rBST adoption is size-biased, too, such that 150 cow herds in the West who are unlikely to be rBST adopters because of their relatively small size would be among the size class of producers in the Upper Midwest who would be highly likely to use rBST. This point is exemplified by the descriptive adoption data reported from a dairy farm community in Texas (Table 2.7 in the Appendix), where the average farm size of rBST adopters is 1,000 cows versus 376 cows for non-adopters. In all of the other state samples included in this study, a herd size of 376 cows would be associated with almost universal adoption of rBST.

Although the analysis developed above does not provide any explanations as to why the size bias in adoption should be a regionally relative size bias, four possibilities are briefly considered here. One popular explanation among dairy industry professionals might be that the regressions presented here do not adequately capture management ability and that such ability is also size biased (i.e. larger herds are run by better managers who are also more likely to adopt rBST). However, the evidence from rBST disadoption and other profitability studies both belie this better manager argument. First, if it were true, then we might expect the coefficient estimates on herd size to distinguish between adopters and disadopters as part of the evidence that adopters are significantly better managers than disadopters. Second, because rBST adoption has been shown to have no statistically significant impacts on dairy farm profitability, there is currently no evidence that rBST adopters earn higher profits (which would be a logical conclusion of the better manager argument).

A second possible explanation for the size bias issue is also related to management strategy, but does not rely on rBST adopters being more profitable. It could be that farms that have specialized their labor tasks are more likely to adopt rBST, because such specialization may be critical for managing the herd in a way that makes rBST use profitable. Then, if herd size at which such specialization is likely to occur varies across regions according to the range of tasks normally taken on by dairy farms, then average herd sizes of farms with and without specialization could vary within regions yet be distinct across regions. For example, it may be that due to less effort being spent on cropping, nutrient management, and certain types of animal care, a non-specialized family labor farm in Texas would have, on average, 300 cows while in

Wisconsin a fully integrated, non-specialized livestock and crop cultivation operation might have 75 cows. By contrast, operations that specialized over the different ranges of tasks across those two states might have, on average, 600 and 150 cows, respectively. Testing this explanation would require more information on management practices and labor allocation than we have in these studies, though Barham, Jackson-Smith, and Moon (1999) find some evidence to support this claim in Wisconsin.

The third and fourth possibilities relate to the information costs and attitudes associated with the adoption of new technologies. In the case of information, larger farm operations might be more able to make the fixed cost investment of learning about the new technology and hence be more likely to adopt, especially early in a technology's diffusion process. This hypothesis seems plausible but less likely for rBST given the extended controversy that preceded its commercialization and, in effect, made information on the technology widely available from the outset. Also, this hypothesis does not explain the size-bias finding across disparate regions. Finally, our last possibility is that attitudes toward rBST and/or new technologies in general might be positively correlated with herd size in all of the locales. This explanation, while plausible, begs the question of why these attitudes would be sustained as the diffusion process of technologies matured. Overall, the size-bias question remains an intriguing avenue for future research, one that could benefit from further comparative work across multiple states with disparate herd size distributions and sufficient information on farm management strategies and attitudes toward new technologies to explore contending explanations.

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Table 1. Farm Characteristics by State

Characteristics	Overall	CT	NY	ID	UT	MN	WI	TX
Sample size	781	117	50	56	58	213	252	35
Percent of total sample	100.0	15.0	6.4	7.2	7.4	27.3	32.3	4.5
Data Collection Year		1998	1997	2000	2000	1999	1996	1999
rBST Adoption Rate								
Currently rBST use on Any Milking Cows	26.4	31.6	44.0	26.8	29.3	27.7	15.5	48.6
Disadopter (tried rBST but no longer use it)	10.9	9.4	14.0	14.3	13.8	20.7	4.3	N/A
Percent of Milk Cow using rBST Currently *	51.3	57.7	50.1	48.4	53.4	52.6	40.7	N/A
Operator Demographics								
Mean age of operator	48.1	53.2	49.5	45.9	51.6	45.7	47.7	43.0
Operator Education Level (percent)								
- Less than High School	10.5	7.5	10.0	1.8	3.4	8.0	18.0	9.1
- High School Diploma	46.2	43.9	38.0	21.4	19.0	63.2	50.2	12.1
- Some College or Trade school	30.4	29.9	28.0	44.6	48.3	23.6	27.3	45.5
- BA Degree or Higher	13.1	18.7	24.0	32.1	29.3	5.2	4.5	33.3
Herd Size and Productivity								
Mean Herd Size (cows)	149.0	118.3	200.8	519.2	175.0	68.5	63.2	677.0
Median Herd Size (cows)	66.0	90.0	127.5	230.0	106.0	57.0	50.0	401.0
State Average Herd Size in Year 1997 (cows) **	68.7	85.7	77.7	194.3	101.1	54.2	55.7	108.0
Rolling Herd Average (lbs/cow/year)	19,826	20,225	21,994	19,918	19,813	20,140	18,720	19,857
Technology Use								
Keep Any Type of Production Record	70.1	64.9	86.0	36.4	50.9	79.2	72.5	80.0
Use of TMR	46.1	62.8	82.0	76.8	62.1	38.5	25.1	62.9
Seasonal Milking	4.2	6.5	0.0	3.8	1.8	4.7	4.1	N/A
Milk Cows Three Times per Day	9.5	11.0	16.0	18.2	15.8	2.3	6.0	40.0
Use Vet. Service Regularly	71.4	80.5	82.0	71.4	69.0	64.6	71.6	N/A
Balanced Feed Rations	74.7	71.4	84.0	78.6	71.9	75.6	73.1	N/A
Use Computer to Manage Farm Records	45.4	50.0	52.0	87.5	74.1	39.8	28.2	62.9

* Conditional on Current rBST User

** Source: USDA Final Estimates of Milk Cows and Milk Production by State in Year 1997 (number of milk cows 1/number of operations)

Table 2. Descriptive Statistics by Sub Groups

Characteristics	Overall	CT-NY	ID-UT	MN-WI	Texas
Non-adopter					
Number of Observation	486	90	66	312	18
Operator Age	49.2	54.2	49.2	48.0	43.7
Use of TMR (%)	30.8	45.5	65.2	19.0	38.9
Keep Production Records (%)	60.6	58.0	34.4	67.0	72.2
Herd Size (cows)	92.3	86.3	207.7	54.1	376.1
Operator Education					
- Less than High School (%)	14.3	12.2	1.5	17.7	11.8
- High School Diploma (%)	48.5	52.4	24.2	54.1	23.5
- Some College or Trade school (%)	28.3	24.4	47.0	24.3	47.1
- BA Degree or Higher (%)	8.9	11.0	27.3	3.9	17.6
Current Adopter					
Number of Observation	206	59	32	98	17
Operator Age	46.2	49.1	47.8	44.5	42.3
Use of TMR (%)	75.6	94.8	81.3	60.2	88.2
Keep Production Records (%)	86.5	87.9	62.5	94.2	88.2
Herd Size (cows)	276.9	222.7	585.8	91.3	996.6
Operator Education					
- Less than High School (%)	4.4	5.2	0.0	5.2	6.3
- High School Diploma (%)	39.9	25.9	12.5	63.9	0.0
- Some College or Trade school (%)	30.5	34.5	37.5	23.7	43.8
- BA Degree or Higher (%)	25.1	34.5	50.0	7.2	50.0
Dis-Adopter					
Number of Observation	89	18	16	55	N/A
Operator Age	46.3	51.2	49.0	44.0	N/A
Use of TMR (%)	61.4	100.0	62.5	49.1	N/A
Keep Production Records (%)	80.9	83.3	43.8	90.9	N/A
Herd Size (cows)	161.2	159.9	423.1	85.4	N/A
Operator Education					
- Less than High School (%)	4.5	0.0	12.5	3.6	N/A
- High School Diploma (%)	46.6	47.1	18.8	54.5	N/A
- Some College or Trade school (%)	40.9	35.3	62.5	36.4	N/A
- BA Degree or Higher (%)	8.0	17.6	6.3	5.5	N/A

Table 3. Multinomial Logit Regression Analysis

Non Adopter - Comparison Group

(Standard Errors in Parentheses)

Variables	CT-NY		ID-UT		MN-WI		MN-WI	
Current Adopter								
Constant	-3.42	***	-5.52	***	-2.75	***	-2.68	***
	(1.32)		(1.85)		(1.01)		(1.02)	
Operator Education	0.90	***	0.82	**	0.18		0.12	
	(0.26)		(0.37)		(0.20)		(0.21)	
Operator Age	-0.04	**	0.009		-0.02		-0.02	
	(0.02)		(0.02)		(0.01)		(0.01)	
Keep Any Type of Production Record	1.39	**	0.98	*	1.72	***	1.46	***
	(0.60)		(0.50)		(0.51)		(0.51)	
Herd Size	0.01	***	0.002	***	0.02	***	0.01	***
	(0.003)		(0.001)		(0.004)		(0.004)	
Regional Dummy [1]	-0.24		0.85		-1.25	***	-1.16	***
	(0.49)		(0.56)		(0.29)		(0.30)	
Use of TMR							0.96	***
							(0.31)	
Dis-adopter								
Constant	-4.22	**	-0.28		-2.90	***	-2.81	**
	(1.77)		(1.68)		(1.12)		(1.12)	
Operator Education	0.48		-0.64	*	0.40	***	0.36	
	(0.33)		(0.38)		(0.24)		(0.24)	
Operator Age	-0.01		0.002		-0.02		-0.02	
	(0.02)		(0.02)		(0.02)		(0.02)	
Keep Any Type of Production Record	0.93		0.39		1.17	**	1.07	**
	(0.73)		(0.60)		(0.51)		(0.52)	
Herd Size	0.01	***	0.001	*	0.02	***	0.02	***
	(0.003)		(0.001)		(0.004)		(0.004)	
Regional Dummy [1]	0.24		0.18		-1.84	***	-1.79	***
	(0.61)		(0.64)		(0.38)		(0.38)	
Use of TMR							0.52	
							(0.36)	
Log Likelihood	-110.94		-90.60		-292.70		-287.75	
Number of Observation	153		112		397		396	

1 Regional Dummies in each subgroup are New York, Utah, and Wisconsin respectively.

Note: single asterisk indicates significance at the 0.1 level; double asterisk at the 0.05 level, and triple asterisk at the 0.01 level.

Table 2.1 Connecticut Characteristics by rBST Adoption

Characteristics	Connecticut Average	Current adopter	Disadopter	Never-adopter
Number of total sample	117	37	11	69
Percent of total sample	100.0	31.6	9.4	59.0
rBST Adoption Rate				
Current Use rBST on Any Milking Cows	31.6	100.0	0.0	0.0
Ever Tried rBST on Any Milking Cows	41.0	100.0	100.0	0.0
Percent of Milk Cow using rBST Currently *	57.7	57.7	N/A	N/A
Operator Demographics				
Mean age of operator	53.2	51.2	53.4	54.2
Operator Education Level (percent)				
- Less than High School	7.5	2.8	0.0	11.5
- High School Diploma	43.9	30.6	40.0	52.5
- Some College or Trade school	29.9	36.1	40.0	24.6
- BA Degree or Higher	18.7	30.6	20.0	11.5
Herd Size and Productivity				
Mean Herd Size (cows)	118.3	176.4	155.9	79.4
Rolling Herd Average (lbs/cow/year)	20,225	22,743	20,821	18,545
Technology Use				
Keep Any Type of Production Record	64.9	80.6	81.8	53.7
Use of TMR	62.8	94.4	100.0	40.3
Seasonal Milking	6.5	5.9	0.0	7.8
Milk Cows Three Times per Day	11.0	32.4	10.0	0.0
Use Vet. Service Regularly	80.5	97.2	90.9	69.7
Balanced Feed Rations	71.4	88.9	90.9	58.5
Use Computer to Manage Farm Records	50.0	80.0	72.7	30.9

* Conditional on Current rBST User

Table 2.2 New York Characteristics by rBST Adoption

Characteristics	New York Average	Current adopter	Disadopter	Never-adopter
Number of total sample	50	22	7	21
Percent of total sample	100.0	44.0	14.0	42.0
rBST Adoption Rate				
Current Use rBST on Any Milking Cows	44.0	100.0	0.0	0.0
Ever Tried rBST on Any Milking Cows	58.0	100.0	100.0	0.0
Percent of Milk Cow using rBST Currently *	50.1	50.1	N/A	N/A
Operator Demographics				
Mean age of operator	49.5	45.6	47.7	54.2
Operator Education Level (percent)				
- Less than High School	10.0	9.1	0.0	14.3
- High School Diploma	38.0	18.2	57.1	52.4
- Some College or Trade school	28.0	31.8	28.6	23.8
- BA Degree or Higher	24.0	40.9	14.3	9.5
Herd Size and Productivity				
Mean Herd Size (cows)	200.8	300.5	166.3	107.9
Rolling Herd Average (lbs/cow/year)	21,994	22,968	25,688	19,700
Technology Use				
Keep Any Type of Production Record	86.0	100.0	85.7	71.4
Use of TMR	82.0	95.5	100.0	61.9
Seasonal Milking	0.0	0.0	0.0	0.0
Milk Cows Three Times per Day	16.0	36.4	0.0	0.0
Use Vet. Service Regularly	82.0	90.9	85.7	71.4
Balanced Feed Rations	84.0	100.0	85.7	66.7
Use Computer to Manage Farm Records	52.0	81.8	71.4	14.3

* Conditional on Current rBST User

Table 2.3 Idaho Characteristics by rBST Adoption

Characteristics	Idaho Average	Current adopter	Disadopter	Never-adopter
Number of total sample	56	15	8	33
Percent of total sample	100.0	26.8	14.3	58.9
rBST Adoption Rate				
Current Use rBST on Any Milking Cows	26.8	100.0	0.0	0.0
Ever Tried rBST on Any Milking Cows	41.1	100.0	100.0	0.0
Percent of Milk Cow using rBST Currently *	48.4	48.4	N/A	N/A
Operator Demographics				
Mean age of operator	45.9	45.4	49.1	45.3
Operator Education Level (percent)				
- Less than High School	1.8	0.0	12.5	0.0
- High School Diploma	21.4	13.3	0.0	30.3
- Some College or Trade school	44.6	26.7	75.0	45.5
- BA Degree or Higher	32.1	60.0	12.5	24.2
Herd Size and Productivity				
Mean Herd Size (cows)	519.2	961.3	685.1	278.0
Rolling Herd Average (lbs/cow/year)	19,918	22,550	19,048	18,953
Technology Use				
Keep Any Type of Production Record	36.4	53.3	50.0	25.0
Use of TMR	76.8	86.7	75.0	72.7
Seasonal Milking	3.8	7.1	0.0	3.1
Milk Cows Three Times per Day	18.2	33.3	28.6	9.1
Use Vet. Service Regularly	71.4	100.0	100.0	51.5
Balanced Feed Rations	78.6	100.0	75.0	69.7
Use Computer to Manage Farm Records	87.5	93.3	100.0	81.8

* Conditional on Current rBST User

Table 2.4 Utah Characteristics by rBST Adoption

Characteristics	Utah Average	Current adopter	Disadopter	Never-adopter
Number of total sample	58	17	8	33
Percent of total sample	100.0	29.3	13.8	56.9
rBST Adoption Rate				
Current Use rBST on Any Milking Cows	29.3	100.0	0.0	0.0
Ever Tried rBST on Any Milking Cows	43.1	100.0	100.0	0.0
Percent of Milk Cow using rBST Currently *	53.4	53.4	N/A	N/A
Operator Demographics				
Mean age of operator	51.6	50.0	48.9	53.1
Operator Education Level (percent)				
- Less than High School	3.4	0.0	12.5	3.0
- High School Diploma	19.0	11.8	37.5	18.2
- Some College or Trade school	48.3	47.1	50.0	48.5
- BA Degree or Higher	29.3	41.2	0.0	30.3
Herd Size and Productivity				
Mean Herd Size (cows)	175.0	254.5	161.1	137.3
Rolling Herd Average (lbs/cow/year)	19,813	22,144	20,403	18,477
Technology Use				
Keep Any Type of Production Record	50.9	70.6	37.5	43.7
Use of TMR	62.1	76.5	50.0	57.6
Seasonal Milking	1.8	0.0	0.0	3.0
Milk Cows Three Times per Day	15.8	43.8	12.5	3.0
Use Vet. Service Regularly	69.0	82.4	75.0	60.6
Balanced Feed Rations	71.9	82.4	75.0	65.6
Use Computer to Manage Farm Records	74.1	94.1	75.0	63.6

* Conditional on Current rBST User

Table 2.5 Minnesota Characteristics by rBST Adoption

Characteristics	Minnesota Average	Current adopter	Disadopter	Never-adopter
Number of total sample	213	59	44	110
Percent of total sample	100.0	27.7	20.7	51.6
rBST Adoption Rate				
Current Use rBST on Any Milking Cows	27.7	100.0	0.0	0.0
Ever Tried rBST on Any Milking Cows	48.4	100.0	100.0	0.0
Percent of Milk Cow using rBST Currently *	52.6	52.6	N/A	N/A
Operator Demographics				
Mean age of operator	45.7	44.2	44.8	46.9
Operator Education Level (percent)				
- Less than High School	8.0	3.4	4.5	11.9
- High School Diploma	63.2	69.5	50.0	65.1
- Some College or Trade school	23.6	18.6	43.2	18.3
- BA Degree or Higher	5.2	8.5	2.3	4.6
Herd Size and Productivity				
Mean Herd Size (cows)	68.5	80.9	89.3	53.6
Rolling Herd Average (lbs/cow/year)	20,140	21,957	20,140	18,566
Technology Use				
Keep Any Type of Production Record	79.2	93.2	90.9	67.0
Use of TMR	38.5	59.3	54.5	20.9
Seasonal Milking	4.7	3.4	2.3	6.4
Milk Cows Three Times per Day	2.3	6.8	0.0	0.9
Use Vet. Service Regularly	64.6	83.1	72.1	51.8
Balanced Feed Rations	75.6	94.9	90.9	59.1
Use Computer to Manage Farm Records	39.8	52.5	44.2	31.2

* Conditional on Current rBST User

Table 2.6 Wisconsin Characteristics by rBST Adoption

Characteristics	Wisconsin Average	Current adopter	Disadopter	Never-adopter
Number of total sample	252	39	11	202
Percent of total sample	100.0	15.5	4.4	80.2
rBST Adoption Rate				
Current Use rBST on Any Milking Cows	15.5	100.0	0.0	0.0
Ever Tried rBST on Any Milking Cows	19.8	100.0	100.0	0.0
Percent of Milk Cow using rBST Currently *	40.7	40.7	0.0	0.0
Operator Demographics				
Mean age of operator	47.7	44.9	40.9	48.7
Operator Education Level (percent)				
- Less than High School	18.0	7.9	0.0	20.9
- High School Diploma	50.2	55.3	72.7	48.0
- Some College or Trade school	27.3	31.6	9.1	27.6
- BA Degree or Higher	4.5	5.3	18.2	3.6
Herd Size and Productivity				
Mean Herd Size (cows)	63.2	107.0	69.9	54.4
Rolling Herd Average (lbs/cow/year)	18,720	21,245	18,524	17,999
Technology Use				
Keep Any Type of Production Record	72.5	96.3	90.9	67.1
Use of TMR	25.1	61.5	27.3	17.9
Seasonal Milking	4.1	7.4	9.1	3.2
Milk Cows Three Times per Day	6.0	20.5	9.1	3.0
Use Vet. Service Regularly	71.6	100.0	90.9	65.4
Balanced Feed Rations	73.1	100.0	90.9	67.1
Use Computer to Manage Farm Records	28.2	46.2	27.3	24.8

* Conditional on Current rBST User

Table 2.6.1 Wisconsin-Athens Characteristics by rBST Adoption

Characteristics	Athens Average	Current adopter	Disadopter	Never-adopter
Number of total sample	111	11	7	93
Percent of total sample	100.0	9.9	6.3	83.8
rBST Adoption Rate				
Current Use rBST on Any Milking Cows	9.9	100.0	0.0	0.0
Ever Tried rBST on Any Milking Cows	16.2	100.0	100.0	0.0
Percent of Milk Cow using rBST Currently *	46.4	46.4	N/A	N/A
Operator Demographics				
Mean age of operator	47.0	37.9	43.4	48.3
Operator Education Level (percent)				
- Less than High School	26.4	0.0	0.0	31.8
- High School Diploma	42.5	45.5	71.4	39.8
- Some College or Trade school	28.3	54.5	14.3	26.1
- BA Degree or Higher	2.8	0.0	14.3	2.3
Herd Size and Productivity				
Mean Herd Size (cows)	58.3	108.2	64.7	52.0
Rolling Herd Average (lbs/cow/year)	18,515	21,009	18,488	18,029
Technology Use				
Keep Any Type of Production Record	68.2	100.0	85.7	63.4
Use of TMR	19.1	45.5	0.0	17.4
Seasonal Milking	5.9	14.3	14.3	4.2
Milk Cows Three Times per Day	5.4	36.4	14.3	1.1
Use Vet. Service Regularly	65.9	100.0	85.7	60.6
Balanced Feed Rations	72.6	100.0	85.7	68.6
Use Computer to Manage Farm Records	29.7	63.6	14.3	26.9

* Conditional on Current rBST User

Table 2.6.2 Wisconsin-Chilton Characteristics by rBST Adoption

Characteristics	Chilton Average	Current adopter	Disadopter	Never-adopter
Number of total sample	76	15	4	57
Percent of total sample	100.0	19.7	5.3	75.0
rBST Adoption Rate				
Current Use rBST on Any Milking Cows	19.7	100.0	0.0	0.0
Ever Tried rBST on Any Milking Cows	25.0	100.0	100.0	0.0
Percent of Milk Cow using rBST Currently *	41.5	41.5	N/A	N/A
Operator Demographics				
Mean age of operator	44.6	42.3	36.5	45.7
Operator Education Level (percent)				
- Less than High School	12.0	13.3	0.0	12.5
- High School Diploma	56.0	66.7	75.0	51.8
- Some College or Trade school	24.0	13.3	0.0	28.6
- BA Degree or Higher	8.0	6.7	25.0	7.1
Herd Size and Productivity				
Mean Herd Size (cows)	63.0	91.3	79.0	54.5
Rolling Herd Average (lbs/cow/year)	19,302	20,881	18,588	18,829
Technology Use				
Keep Any Type of Production Record	83.6	90.0	100.0	80.9
Use of TMR	32.9	60.0	75.0	22.8
Seasonal Milking	4.8	10.0	0.0	4.2
Milk Cows Three Times per Day	5.3	6.7	0.0	5.3
Use Vet. Service Regularly	82.3	100.0	100.0	77.1
Balanced Feed Rations	77.4	100.0	100.0	70.8
Use Computer to Manage Farm Records	26.3	33.3	50.0	22.8

* Conditional on Current rBST User

Table 2.6.3 Wisconsin-Richland Center Characteristics by rBST Adoption

Characteristics	Richland Center Avg.	Current adopter	Disadopter	Never-adopter
Number of total sample	59	13	0	46
Percent of total sample	100.0	22.0	0.0	78.0
rBST Adoption Rate				
Current Use rBST on Any Milking Cows	22.0	100.0	no	0.0
Ever Tried rBST on Any Milking Cows	22.0	100.0	no	0.0
Percent of Milk Cow using rBST Currently *	36.0	36.0	N/A	N/A
Operator Demographics				
Mean age of operator	52.9	53.9	no	52.6
Operator Education Level (percent)				
- Less than High School	12.1	8.3	no	13.0
- High School Diploma	56.9	50.0	no	58.7
- Some College or Trade school	27.6	33.3	no	26.1
- BA Degree or Higher	3.4	8.3	no	2.2
Herd Size and Productivity				
Mean Herd Size (cows)	74.4	124.1	no	60.4
Rolling Herd Average (lbs/cow/year)	18,328	21,917	no	16,534
Technology Use				
Keep Any Type of Production Record	64.3	100.0	no	53.1
Use of TMR	28.8	76.9	no	15.2
Seasonal Milking	0.0	0.0	no	0.0
Milk Cows Three Times per Day	8.5	23.1	no	4.3
Use Vet. Service Regularly	66.7	100.0	no	56.3
Balanced Feed Rations	69.0	100.0	no	59.4
Use Computer to Manage Farm Records	28.8	46.2	no	23.9

* Conditional on Current rBST User

Table 2.10 Texas Characteristics by rBST Adoption

Characteristics	Texas Average	Adopter	Non-adopter
Number of total sample	35	17	18
Percent of total sample	100.0	48.6	51.4
rBST Adoption Rate			
Current Use rBST on Any Milking Cows	48.6	100.0	0.0
Ever Tried rBST on Any Milking Cows	N/A	N/A	N/A
Percent of Milk Cow using rBST Currently *	N/A	N/A	N/A
Operator Demographics			
Mean age of operator	43.0	42.3	43.7
Operator Education Level (percent)			
- Less than High School	9.1	6.3	11.8
- High School Diploma	12.1	0.0	23.5
- Some College or Trade school	45.5	43.8	47.1
- BA Degree or Higher	33.3	50.0	17.6
Herd Size and Productivity			
Mean Herd Size (cows)	677.0	996.6	376.1
Rolling Herd Average (lbs/cow/year)	19,857	20,808	18,843
Technology Use			
Keep Any Type of Production Record	80.0	88.2	72.2
Use of TMR	62.9	88.2	38.9
Seasonal Milking	N/A	N/A	N/A
Milk Cows Three Times per Day	40.0	52.9	27.8
Use Vet. Service Regularly	N/A	N/A	N/A
Balanced Feed Rations	N/A	N/A	N/A
Use Computer to Manage Farm Records	62.9	82.4	44.4

* Conditional on Current rBST User

** 2 farms report the percentage of milk cows using rBST currently even though they are not current rBST users.

Table 2.11 Maine Characteristics by rBST Adoption

Characteristics	Maine Average	Current adopter	Disadopter	Never-adopter
Number of total sample	29	6	2	21
Percent of total sample	100.0	20.7	6.9	72.4
rBST Adoption Rate				
Current Use rBST on Any Milking Cows	20.7	100.0	0.0	0.0
Ever Tried rBST on Any Milking Cows	27.6	100.0	100.0	0.0
Percent of Milk Cow using rBST Currently *	68.4	66.3	75.0 **	N/A
Operator Demographics				
Mean age of operator	51.6	46.5	38.0	54.3
Operator Education Level (percent)				
- Less than High School	3.4	0.0	0.0	4.8
- High School Diploma	51.7	83.3	0.0	47.6
- Some College or Trade school	31.0	0.0	100.0	33.3
- BA Degree or Higher	13.8	16.7	0.0	14.3
Herd Size and Productivity				
Mean Herd Size (cows)	147.0	142.8	55.0	156.9
Rolling Herd Average (lbs/cow/year)	17,574	20,129	19,750	16,636
Technology Use				
Keep Any Type of Production Record	42.9	33.3	50.0	45.0
Use of TMR	39.3	66.7	100.0	25.0
Seasonal Milking	0.0	0.0	0.0	0.0
Milk Cows Three Times per Day	7.1	16.7	0.0	5.0
Use Vet. Service Regularly	71.4	66.7	50.0	75.0
Balanced Feed Rations	64.3	100.0	100.0	50.0
Use Computer to Manage Farm Records	37.0	60.0	100.0	25.0

* Conditional on Current rBST User

** 2 farms report the percentage of milk cows using rBST currently even though they are not current rBST users.