AgBioForum – Volume 4, Number 2 – 2001 – Pages 115-123

THE ESTIMATED PROFIT IMPACT OF RECOMBINANT BOVINE SOMATOTROPIN ON NEW YORK DAIRY FARMS FOR THE YEARS 1994 THROUGH 1997

Loren W. Tauer[1]

Data from New York dairy farms for the years 1994 through 1997 were used to estimate whether recombinant bovine Somatotropin (rbST) generated profits for adopters. Results show that the estimated profit impact of rbST, although generally positive, was statistically zero. Herd average milk production per cow clearly increased with rbST use.

Key Words: dairy; profitability; rbST; recombinant bovine Somatotropin.

Bovine Somatotropin is a hormone produced by the dairy cow that regulates milk production. The genetic material for this compound has been isolated and is produced by recombinant biotechnology. This recombinant-produced bovine Somatotropin can then be injected into the dairy cow to augment her naturally produced levels of this hormone, enhancing milk production, but requiring additional feed and other inputs to increase milk production. The compound recombinant bovine Somatotropin (rbST) has been commercially available to United States (US) dairy producers since February of 1994. Monsanto is the only US supplier of recombinant bST under the registered trade name POSILAC®.

Before approved for sale, rbST was subject to years of investigation and testing. Given the large production response per cow that most of these tests reported, rbST was generally projected to be profitable for dairy farmers, with estimates often exceeding $100 per year per cow (Butler, 1992), although some projected little or no profit (Marion & Wills, 1990). Now that US farmers have used rbST for a number of years, it is possible to estimate their actual production and profit responses.

Tauer and Knoblauch (1997) used data from the same 259 New York producers in 1993 and 1994 to estimate the impact of rbST on milk production per cow and return above variable cost per cow change between these two years. Recombinant bST was not available in 1993, but one-third of these farmers used rbST in 1994. The use of rbST had a positive and statistically significant impact on average production per cow (□ = 0.01), but the profit effect, although positive and large, was not statistically different from zero (□ = 0.14).

Stefanides and Tauer (1999) also analyzed the production and profit effects using the same data source, but included data from 1995, resulting in a panel data set of 211 farms. They corrected for self-selection bias by using the two-step Heckman approach, and estimated a probit adoption function for each year (Greene, 1997). They likewise found a statistically significant and positive

[1] *Loren Tauer is a Professor in the Department of Applied Economics and Management at Cornell University in Ithaca, New York.*

effect on milk production per cow from the use of rbST, but found that the impact of rbST on profits was statistically zero.

Ott and Rendleman (2000) used 1996 United States Department of Agriculture (USDA) dairy data, and from actual farm rbST response concluded that the optimal rbST use would be 73 percent of the herd, with a herd milk response of 2,983 pounds per cow. Unfortunately, that data set did not collect cost information, but using cost budgets they found that rbST would increase profits by $126 per cow.

This paper extends findings on New York farms by studying four years of rbST use data (1994 through 1997) to determine the profit per cow from rbST for each of those four years. A number of models are estimated. The first is an rbST use dummy variable regression assuming the only difference between the users and non-users is the use of rbST. A probit adoption function is then used to correct for self-selection bias. A more extensive profit function is also estimated controlling for self-selection bias.

Models

The data are from a group of farms, some of which used rbST. The intent is to determine whether the use of rbST increased profits for those farmers using rbST. If determinants of profit are distributed randomly across farms that use and do not use rbST, then farms can simply be sorted into rbST users and non-users and dummy variable regression can be used to test whether the use of rbST has an impact on farm profits. The regression model is specified as follows,

$$w_i = a + \delta u_i + \varepsilon_i \qquad (1)$$

where, *w* is profit per farm, *a* is an intercept, δ is the rbST impact with *u* as a measure of whether rbST is used, and ε is the error term with *i* as the index for farms.

However, the potential exists for self-selection bias in this test since farmers themselves determined their use or non-use of rbST. Farmers that use rbST may be more or less profitable as a group even without the use of rbST. The result is that the error term, ε, may be correlated with the rbST treatment effect, δ, leading to bias in the estimated impact. There are a number of remedies to this data limitation, most of which involve the estimation of a separate equation explaining the selection decision, and using the prediction from that equation to correct for self-selection bias. This selection process equation can also be estimated separately or simultaneously with the rbST impact equation by Maximum Likelihood Estimation. Here probit adoption functions are estimated and used to sort farmers into rbST users and non-users. The treatment effect of rbST is then estimated by both the Heckman two-step procedure and Maximum Likelihood Estimation of the adoption and rbST impact variables (see section 15.8 of Davidson and MacKinnon (1993)).

It is also possible that not only do characteristics of the farms determine whether farmers use rbST, but farm characteristics themselves may determine farm profit. To incorporate this concept, an explanatory profit function is further modeled as a function of farm characteristics. The profit w_i of farm *i* is specified as follows,

$$w_i = a + \beta x_i + \delta u_i + \varepsilon_i \qquad (2)$$

where, u_i denotes the use of rbST on farm *i* and δ is the impact of rbST use on profit, x_i represents observed exogenous variables for farm *i* and β is the impact of those variables on profit, *a* is the intercept, and ε is the error term. The rbST adoption function is modeled again as a probit function and estimated with equation (2) by Maximum Likelihood Estimation. All estimation was done using the software LIMDEP (1998).

Data

The data were from the New York Dairy Farm Business Summary (DFBS) Program for the years 1994 through 1997 (Knoblauch & Putnam, 1998). This is a record collection and analysis project primarily meant to assist dairy farmers in managing their operations. Variable specification is consistent with the annual Dairy Farm Business Summary Report. The average and standard deviation of these data for the year 1997 are reported in table 1.

Table 1: Definition of Variables.

Variables	Definition	Mean 1997	S.D. 1997
SRPCOW	Milk receipts minus operating cost per cow ($)	377.00	359.00
MILKCOW	Milk production per cow (pounds)	18,739.00	3,359.00
COWS	Average number of cows	183.00	243.00
MILKPR	Milk price per cwt.	13.70	0.73
AGE	Age of principal owner in years	48.00	89.00
BUS_ORG	Business organization, 1 if multiple owner	0.39	
EDUC	Education, 1 if more than high school	0.54	

N = 280 observations for 1997

This is not a random sample. It represents a population of farmers that actively participate in agricultural extension and research programs. Slightly less than one-half of the participants each year participated in the other three years of the survey. The farms are larger on average than New York dairy farms and they experience higher levels of production per cow. Yet, there is a significant amount of heterogeneity in the data. The smallest farm has only 29 cows, while the largest has over 2,000 cows. The average number of cows is 183.

The DFBS surveys for each of the four years asked farmers to indicate their use of rbST in one of five categories as follows: (0) not used at all; (1) stopped using it during the year; (2) used on less than 25 percent of the herd; (3) used on 25-75 percent of the herd; or (4) used on more than 75 percent of the herd. Most responses over the period were in categories 0 and 3. Very few farms indicated they used it on more than 75 percent of the herd. Likewise, few farms used it on less than 25 percent of the herd.

This rbST use coding has limited informational content. Although most of these farms are DHIA (Dairy Herd Improvement Association) members, that organization does not code rbST use on individual cow records, so neither age nor production level of individually treated cows was known. This lack of detailed rbST management information precludes analysis on rbST use tactics, which may be complex and unique by farm. Farmers using rbST must believe that it is profitable on their farms. As such, farms were simply sorted into rbST users if they checked categories 2, 3, or 4 and non-users if they checked categories 0 or 1.

Empirical Results

The dummy variable regression without rbST treatment selection correction estimated rbST profit impacts per cow of $46, $64, $88, and $73 for the years 1994, 1995, 1996, and 1997, respectively (table 2). Although these are all positive values, the t-statistics (coefficient/standard error) are all less than 2. One must conclude then that statistically the impact of rbST, on average, for the farms that used rbST was zero.

Table 2: Estimated Impact of RbST on Profits Per Cow, Dummy Variable Regression (Coefficient Estimate Divided by Standard Error in Parentheses).

Variable	1994	1995	1996	1997
Intercept	580	468	550	343
	(24.75)*	(18.66)*	(18.12)*	(11.76)*
rbST Impact ($)	46	64	88	73
	(1.27)	(1.72)	(1.99)	(1.71)
Adjusted R-squared	0.00	0.01	0.01	-0.01
Number of Observations	324	329	307	280

* Indicates statistically different from zero at probability = 0.05.

Binary probit adoption functions were estimated for each year, and results show that age has a negative impact on adoption, and a multi-owned business has a positive impact on adoption (table 3). However, the standard errors were almost as large as the coefficient estimates. It is clear, however, that education and farm size have positive and statistically significant impacts on adoption. Large-scale farmers who have more than a high school education are more likely to adopt rbST. These results are similar to dairy farmers who adopted rbST in Wisconsin (Barham, Jackson-Smith & Moon, 2000).

The probit adoption functions were then used to adjust for selection bias in the dummy variable regression. Two approaches were used. The Heckman two-step procedure used the probit results to compute the inverse Mill's ratio, and that value was included as a variable in the rbST dummy variable regression. The estimated coefficient on the inverse Mill's ratio is lambda in table 4. Lambda is positive in 3 of the 4 years, which would imply selection bias such that more profitable farms elect to use rbST. However, since the standard errors of the lambda estimates are large, one should conclude that there is no sample selection bias present. This is the same result found by Stefanides and Tauer. The rbST profit impacts are inconsistent, but none are statistically different from zero.

The Maximum Likelihood Estimation procedure allowed lambda to be decomposed and estimated into $\lambda = \rho\sigma$, where σ is the standard deviation of the impact equation error term, and ρ is the correlation between the impact and selection equation error terms. A positive ρ implies that rbST selection and rbST profit impact are positively correlated, such that more profitable farms are more apt to adopt rbST. As table 4 shows, however, the correlation is negative in two of the four years, and in all four years the standard errors of the estimates are large, so one must conclude that the correlation is essentially zero statistically. There apparently is no rbST selection bias.

Table 3: Binary Probit Model Estimates for RbST Adoption, Maximum Likelihood Estimation (Coefficient Estimate Divided by Standard Error in Parentheses).

Variable	1994	1995	1996	1997
Intercept	-3.79	-3.98	-3.71	-5.60
	(-5.63)*	(-6.19)*	(-5.62)*	(-8.22)*
Education	0.25	0.35	0.33	0.55
	(1.61)	(2.25)*	(2.08)*	(3.18)*
Age	-0.014	-0.014	-0.012	-0.002
	(-1.76)	(-1.85)	(-1.39)	(-0.87)
Business Organization	0.40	-0.03	-0.68	0.003
	(2.21)*	(-0.20)	(-0.39)	(0.02)
Log (cows)	0.84	0.93	0.86	1.11
	(6.76)*	(7.38)*	(7.05)*	(7.77)*
Number of Observations	324	329	307	280

* Indicates statistically different from zero at probability = 0.05.

Since other variables may impact profit and may differ between rbST and non-rbST users, table 5 reports results where profit per cow is estimated as a function of rbST use and other farm variables. RbST use is again modeled as a probit adoption function. Both functions are estimated simultaneously using Maximum Likelihood Estimation. Results are shown in table 5. (Heckman two-step estimates of the rbST impact are also reported.)

RbST impacts for all years are positive, although the standard errors are so large that statistically one must conclude that the impacts are zero. The determining factor for profitability in any of the four years is the milk price received. The estimated rho coefficients are, again, all statistically zero, implying no existence of selection bias. The Heckman two-step estimates of the impact of rbST were negative for three of the four years, but again none of these estimates was statistically different from zero.

The ability to measure determinants of farm profitability is challenging since there are numerous causation factors, many of which cannot be quantified. The models specified here failed to measure a statistically significant impact of rbST on farm profitability. One reason may be an incorrect model specification. To test that possibility, the same model as reported in table 5 was estimated substituting herd average milk production per cow for the previous dependent variable of profits per cow. The results are reported in table 6.

The major difference in the results is that, where previously the price of milk largely determined profit per cow, now education and farm size determine production per cow. Another major difference is that now rbST has a positive and statistically strong impact on production per cow, whereas rbST use did not have a statistically measured impact on profit per cow. This impact ranged from a low of 2,668 pounds per cow in 1994 to a higher response of 3,466 pounds per cow in 1996. These output responses are similar to those found in Ott and Rendleman (2000) using 1996 USDA dairy data.

Table 4: Estimated Impact of RbST on Profits Per Cow, Adjusting for Selection Bias with Adoption Function (Coefficient Estimate Divided by Standard Error in Parentheses).

Variable	1994	1995	1996	1997
		-- Heckman Two-Step Procedure --		
Intercept	607	433	569	378
	(16.80)*	(10.92)*	(11.39)*	(9.26)*
rbST Impact ($)	-17	140	47	-2
	(-0.23)	(1.85)	(0.49)	(-0.03)
Lambda	49	-60	31	66
	(0.96)	(-1.16)	(0.49)	(1.23)
		-- Maximum Likelihood Estimates --		
Intercept	544	491	514	352
	(14.39)*	(12.56)*	(9.70)*	(8.35)*
rbST Impact ($)	31	67	84	75
	(0.70)	(1.59)	(1.71)	(1.59)
Sigma	324	334	387	357
	(25.18)*	(30.15)*	(26.50)*	(26.16)*
Rho	.21	-0.11	0.15	-0.45
	(1.06)	(-0.70)	(0.72)	(-0.26)
Adoption Estimates		*Similar to Table 3*		
Number of Observations	324	329	307	280

* Indicates statistically different from zero at probability = 0.05.

Table 5: Estimated Impact of RbST and Other Variables on Profits Per Cow, Maximum Likelihood Estimation (Coefficient Estimate Divided by Standard Error in Parentheses).

Variable	1994	1995	1996	1997
Intercept	-188	-174	-996	-1121
	(-0.39)	(-0.35)	(-2.02)*	(-2.74)*
rbST Impact ($)	19	49	81	63
	(0.38)	(1.10)	(1.47)	(1.20)
Education	41	18	90	59
	(1.13)	(0.47)	(2.00)*	(1.36)
Age	-1.66	-2.27	1.98	-0.24
	(-0.99)	(-1.16)	(0.87)	(-0.26)
Milk Price	60	58	93	108
	(1.68)	(1.55)	(2.85)*	(3.70)*
Number of Cows	-0.04	0.05	-0.04	-0.10
	(-0.26)	(0.44)	(-0.17)	(-0.54)
Sigma	320	331	379	347
	(25.29)*	(28.62)*	(24.71)*	(27.11)*
Rho	0.18	-0.92	0.01	-0.11
	(0.88)	(-0.53)	(0.43)	(-0.58)
Adoption Estimates	*Similar to Table 3*			
	-- Heckman Two-Step Estimate of rbST --			
rbST Impact ($)	-130	83	-85	-112
	(-1.27)	(0.73)	(-0.59)	(-1.02)
Lambda	120	-26	116	121
	(1.68)	(-0.37)	(1.27)	(1.71)
Additional Variables	*Similar to above estimates*			
Number of Observations	324	329	307	280

* Indicates statistically different from zero at probability = 0.05.

Table 6: Estimated Impact of RbST and Other Variables on Herd Production Per Cow, Maximum Likelihood Estimation (Coefficient Estimate Divided by Standard Error in Parentheses).

Variable	1994	1995	1996	1997
Intercept	21,320	16,110	16,634	13,560
	(7.30)*	(5.40)*	(4.70)*	(5.11)*
rbST Impact	2,668	2,953	3,466	2,973
	(7.89)*	(8.75)*	(9.33)*	(7.58)*
Education	1,009	644	1,021	966
	(3.64)*	(2.21)*	(3.19)*	(3.02)*
Age	-18	13	0.33	3
	(-1.42)	(0.89)	(0.02)	(1.39)
Milk Price	-261	-19	-90	175
	(-1.21)	(-0.08)	(-0.38)	(0.91)
Number of Cows	2.12	2.65	3.09	3.74
	(3.93)*	(5.19)*	(6.01)*	(3.67)*
Sigma	2,334	2,525	2,699	2,603
	(27.28)*	(26.74)*	(22.07)*	(23.61)*
Rho	0.007	0.19	0.27	0.03
	(0.04)	(1.08)	(1.41)	(0.20)
Adoption Estimates	*Similar to table 3*			
Number of Observations	324	329	307	280

* Indicates statistically different from zero at probability = 0.05.

Conclusions

Data from New York dairy farms for the years 1994 through 1997 were used to determine if rbST generates profits for adopters. RbST has been commercially available since 1994 and approximately half of these farms used rbST during that time. On average, farms that are using rbST are not profiting from its use, although they are experiencing an output response. This study supports earlier results found by Tauer and Knoblauch (1997), and Stefanides and Tauer (1999) using earlier years of this data set.

Why do New York dairy farmers use rbST when the profit impact appears to be non-existent? Although statistically zero, the impact estimates are generally numerically positive, and often approach $100 per cow. These results are for the treatment average. It may be that there are farms profiting from the use of rbST. The implication, then, is that some farmers may be losing money using rbST. But since the output impact of rbST is unambiguously positive, it may be difficult for individual farmers to determine if that output impact is translating into a profit.

Should a dairy farm use rbST? Although a strongly statistical positive profit response for rbST was not estimated, the estimated response was often numerically positive, suggesting a profit potential. Farmers must carefully assess their individual decisions. Production and financial controls are necessary to ascertain the impact of rbST and other changes and decisions they make in their farm businesses.

References

Barham, B.L., Jackson-Smith, D., and Moon, S. (2000). The adoption of rBST on Wisconsin dairy farms. AgBioForum, 3(2&3), 181-187. Available on the World Wide Web: http://www.agbioforum.org.

Butler, L.J. (1992). Economic evaluation of bST for on-farm use. In M.C. Hallberg (Ed.), Bovine Somatotropin and Emerging Issues: An Assessment, (pp. 145-171). Boulder, CO: Westview Press.

Davidson, J. and MacKinnon, J. (1993). Estimation and inference in econometrics. New York: Oxford Press.

Econometric Software, Inc. (1998). LIMDEP, Version 7.0. [Econometric computer Software]. Plainview, NY: Author.

Greene, W. (1997). Econometric analysis. Englewood Cliffs, NJ: Prentice Hall.

Knoblauch, W.A. and Putnam, L.D. (1998). Dairy Farm Management Business Summary, New York State, 1997 (Research Bulletin No. 98-06). Ithaca, NY: Department of Agricultural, Managerial, and Resource Economics, Cornell University.

Marion, B.W. and Wills, R.L. (1990). A prospective assessment of the impacts of bovine Somatotropin: A case study of Wisconsin. American Journal of Agricultural Economics 72, 326-336.

Ott, S.L. and Rendleman, C.M. (2000). Economic impacts associated with bovine Somatotropin (BST) use based on survey of US dairy herds. AgBioForum, 3, 173-180. Available on the World Wide Web: http://www.agbioforum.org.

Stefanides, Z. and Tauer, L.W. (1999). The empirical impact of bovine Somatotropin on a group of New York dairy farms. American Journal of Agricultural Economics 81, 95-102.

Tauer, L.W. and Knoblauch, W.A. (1997). The empirical impact of bST on New York dairy farms. Journal of Dairy Science 80, 1092-1097.