AgBioForum, 9(2): 79-83. ©2006 AgBioForum.

Impact of Recombinant Bovine Somatotropin on Dairy Farm Cost of Production: Evidence from Multiyear Data

Loren W. Tauer
Cornell University

New York dairy farm data over the years 1994–2002 were used to estimate the impact of recombinant bovine somatotropin (rbST) use on the cost of producing a hundredweight of milk. Both fixed and random effects models were estimated. Self-selection bias in the use of rbST was not found to exist. Results imply that the use of rbST on these dairy farms reduces the net cost of producing a hundredweight of milk somewhere between \$0.23 and \$0.52. For 20,000 pound average per-cow production, this would be a net cost reduction of \$46–104 per cow.

Key words: profitability of biotechnology, recombinant bovine somatotropin.

Introduction

Recombinant bovine somatotropin, referred to as rbST and commonly called BST, has been commercially available to US dairy producers from the Monsanto Company since February of 1994 under the registered trade name POSILAC. Bovine somatotropin is a hormone produced naturally by the dairy cow that regulates milk production. The genetic material for this compound has been isolated by genetic engineering and produced by recombinant biotechnology. This recombinant-produced bovine somatotropin (rbST) can 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 achieve increased milk production.

RbST was subject to years of investigation and testing before approval for commercial sale in the United States. Given the large per-cow production response 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 analysts projected little or no profit (Marion & Wills, 1990). Now that rbST has been available and used by farmers, numerous studies have attempted to assess the profitability on dairy farms. Generally, the results of these studies are ambiguous. Most find a positive (but not statistically significant) effect of rbST on farmers' profits.

Tauer and Knoblauch (1997) were the first to estimate the impact of rbST on per-cow milk production and return above variable cost. Using data from the same 259 New York producers in 1993 and 1994, they found the use of rbST had a positive and statistically significant impact on the change in average per-cow production between the two years; however, the profit change, although positive and large, was not statistically different from zero. Using one more year of data, Stefanides and Tauer (1999) likewise found a statistically significant positive effect on milk production per cow from the use of rbST and found the impact of rbST on profits was statistically zero, although numerically positive. Tauer (2001b) used this same data source but also included data from 1996 and 1997. Positive profit rbST treatment coefficients were generally estimated, but the standard errors were so large that statistically the profit impact was zero.

Foltz and Chang (2002) sampled all Connecticut dairy farms for the 1998 production year and found that rbST had a positive and statistically significant effect on milk production, but the impact on profits was statistically zero, although numerically negative. McBride, Short, and El-Osta (2003) used a random sample of US dairy farms and found an increase in per-cow milk production with rbST adoption, but the estimated profitability impact was not statistically different from zero. Ott and Rendleman (2000) used actual milk production experienced on rbST adopting farms, but because they did not have actual cost changes, they imputed costs and returns in a partial budget framework. They concluded that rbST would increase profits by \$126 per cow, similar to previous ex ante impact studies.

Most of these studies estimated rbST profitability impacts that were numerically positive, but due to large standard errors on these estimates, the impacts were concluded to be not statistically different from zero. Nevertheless, many farmers continue to use the product. Type I error aside, it is notoriously difficult to quantify and estimate the determining factors of farm-level profitability. Profits across farms and years are extremely variable and are subject to weather, pests, and other stochastic and difficult-to-measure determinants. One way to wash out these stochastic components is to use more

Table 1. Definition of variables.

Variable	Definition	Average value (standard deviation)
TOTCOST_CWT	Total cost to produce a hundredweight of milk	$15.79 ($2.96)
BSTD	1 If used on farm; 0 otherwise	0.50
COWS	Number of average cows in the herd	206 (265)
PARLOR	1 If parlor; 0 otherwise	0.58
OPERATOR_AGE	Age of the sole or principal operator in years	48 (10)
EDUC_DUM	1 If post high school; 0 otherwise	0.57

observations. Most previous rbST impact assessments only used several hundred observations, typically from only one production year. Additional years of rbST use data are now available; more farm observations over more years may permit a clearer picture of the impact of rbST. Thus, this article revisits the profitability impact of rbST but uses data from 1994 (the first year of rbST use) through 2002. Over that nine-year period there are 2,619 dairy farms records available from New York producers.

This analysis uses cost of producing a hundredweight of milk as the performance variable, whereas most previous analysis typically used some alternative measure of profitability, such as per-cow profits. The limitation of per-cow profits—even when all costs of production are accounted for, including unpaid operator and family labor—is that a large operation may be comparatively more satisfied with lower per-cow profits than a very small farm. Cost of production per hundredweight clearly measures the economic impact of rbST. In a competitive market, farms that produce at the lowest cost per unit of output will be profitable over time. Society also benefits from technology that reduces unit cost of production.

Data

Data are from the New York Dairy Farm Business Summary Program (Knoblauch & Putnam, 1998), which is the same data source used by Tauer and Knoblauch (1997), Stefanides and Tauer (1999), and Tauer (2001b) to assess the impact of rbST. This is a voluntary record collection and analysis project primarily meant to assist dairy farmers in managing their operations. It is not a random sample. It represents a population of farmers that actively participate in agricultural extension and research programs. The farms in this sample are larger than average New York dairy farms, and they experience higher levels of production per cow. To be included in this data set, milk receipts must constitute at least 90% of total farm receipts.

Over the nine-year period of 1994–2002, a total of 675 unique farms participated in the survey for an average of 3.88 years, producing 2,619 total observations. Most of these 675 farms either used or did not use rbST over the full duration of this period, although 125 farms used rbST some but not every year.

Variable specification is consistent with the annual Dairy Farm Business Summary Report (DFBS) and is shown in Table 1. A limited number of exogenous variables are collected, including age of the milk producer, education, number of cows, and type of milking system. The performance variable used is the total cost of producing milk per hundredweight. Total cost includes opportunity cost to unpaid operator and family labor as well as equity.

The DFBS surveys for each year asked farmers to indicate their use of rbST in one of five categories as follows: (0) did not use rbST at all; (1) stopped using rbST during the year; (2) used rbST on less than 25% of the herd; (3) used rbST on 25–75% of the herd; or (4) used rbST on more than 75% of the herd. Most responses were in categories 0 and 3. Very few farms indicated they used rbST on more than 75% of the herd; likewise, few farms used it on less than 25% of the herd. These groups pertain to the percentage of cows that were treated during lactation. The usage categories are not concisely defined, so farms were simply sorted as rbST users if they checked categories 2, 3, or 4 and non-users if they checked categories 0 or 1.

Results

Self-selection bias is always a concern when the control variable (in this case rbST) is chosen by the farmer. Farmers who use rbST may be more or less profitable without the use of rbST, which carries over as a return to rbST when the return to rbST is estimated, unless that relationship is modeled or controlled. The results reported below were first estimated controlling for self-selection bias by using the Heckman (1979) two-step procedure. First, a probit adoption equation was estimated. That estimate is shown in Table 2, where farm

Table 2. Adoption estimate of rBST.

Variable	Coefficient estimate	*t*-statistic
Probit adoption equation		
INTERCEPT	-3.92	-16.27***
LOGCOWS	0.79	16.52***
PARLOR	0.20	2.85***
OPERATOR_AGE	-0.01	-2.44**
EDUC_DUM	0.44	7.85***
χ^2 **value**	808.76***	

**Statistically significant at ρ = 0.10.*
***Statistically significant at ρ = 0.05.*
****Statistically significant at ρ = 0.01.*

size (as measured by the number of cows), use of a parlor, younger age of the milk producer, and more than a high school education increased the probability of adoption of rbST. The inverse Mills ratio was then computed from that equation for each observation and inserted as a variable in the rbST impact regression equation (Greene, 1997). The estimated coefficient on the inverse Mills ratio ranged from negative to positive values in various models, with the absolute value of the *t*-statistic of these estimated coefficients never exceeding 1.15, implying no self-selection bias. Previous rbST research using this data source also did not find self-selection bias in these data (Stefanides & Tauer, 1999; Tauer, 2001b).

It may be that the self-selection of whether to participate in the DFBS record keeping system is in itself purging all but the best managers from the data source. All the farmers are good managers, not just the farmers who decide to use rbST. If that is indeed the case, then the results must be interpreted as applicable for only the best farm managers. The impact of rbST on poor farm managers may be different.

Previous analysis using these data found very few exogenous variables that influence profitability (Tauer, 2001b). Per-cow production impacts profits, but per-cow production is not an exogenous or even a management variable. Instead, it reflects the result of management decisions on genetics, feeding, disease control, and cow comfort. Tauer (2001a) found that size as measured by the number of dairy cows was a very significant determinant of cost of production, so the analysis includes the natural log value of the number of cows as a variable. Other variables used were those included in the adoption equation. The rbST variable included in the impact regression is simply whether rbST is used on the farm, entered as a dummy variable of 1 if used and 0 if not used.

Results without modeling a self-selection effect are reported in Table 3. The first results are from a classical linear regression; these show that the use of rbST reduces cost of production by $0.52 per hundredweight of milk produced on these farms. This rbST impact estimate is highly statistically significant using a two-tailed *t*-test. Other variables which impact cost of production per hundredweight of milk are farm size measured by the number of cows on the farm, which decreases costs, and greater operator age, which increases costs. The use of a parlor does not appear to impact costs, although all large farms use milking parlors, and large farms have lower cost of production.

Controlling for farm effects via dummy variables for farms results in a rbST cost reduction estimate of $0.21 per hundredweight, but this was not statistically significant for a two-tailed *t*-test, although presuming rbST should reduce costs, a one-tailed *t*-test would find this estimate statistically significant at the probability level of 0.10. This rbST impact estimate is lower than without farm effects modeled, because individual farm effects pick up some of the cost decrease. This was the only regression where the education level of the farmer impacted the cost of production, and then surprisingly increasing cost by $0.61 per hundredweight of milk produced for farmers who have more than a high school education. Adding year dummy variables to the farm dummy variables (fixed effects) estimates that the use of rbST decreases cost by $0.23 per hundredweight of milk produced; this is statistically significant at the $p = 0.10$ level.

A random farm effects but no year effects model estimates the rbST impact to reduce cost by $0.40 per hundredweight, but the Hausman test of fixed versus random effects concludes that the previous fixed effects results should be preferred, with a rbST impact of $0.21. Adding year fixed effects to the farm random effects results in a cost reduction estimate from the use of rbST as $0.31, and now the Hausman test of fixed versus random effects concludes that the random effects is preferred. Increased number of cows on the farm decreases cost, while increased age of the operator increases cost.

The impact of rbST in the various regressions reduced the cost of milk production from a high of $0.52 to a low of $0.21, with the random farm effects and fixed year effects estimate at $0.31 per hundredweight of milk produced. For 20,000 pounds of production per cow per year, a cost savings of $0.31 per hundredweight equates to $62 per cow. It appears that the use of rbST decreases unit cost of production and is therefore profitable to use.

Table 3. Estimates of the impact of BST on cost of producing a hundredweight of milk.

Variable	Coefficient estimate	*t*-statistic
Least squares		
BSTD	-0.52	-4.26***
LOGCOWS	-1.37	-16.10***
PARLOR	0.12	0.85
OPERATOR_AGE	0.02	4.65***
EDUC_DUM	-0.15	-1.35
INTERCEPT	21.58	51.08***
Adjusted R^2	0.20 F[5,2613]=132.00***	
Least squares with farm dummy variables (fixed effects)		
BSTD	-0.21	-1.41
LOGCOWS	-0.75	-3.03***
PARLOR	-0.06	-0.21
OPERATOR_AGE	0.04	5.15***
EDUC_DUM	0.61	2.58***
Adjusted R^2	0.65 F[677,1941]=8.05***	
Least squares with farm fixed effects and year dummy variables		
BSTD	-0.23	-1.67*
LOGCOWS	-2.23	-8.36***
PARLOR	0.13	0.48
OPERATOR_AGE	0.02	2.51**
EDUC_DUM	0.32	1.46
INTERCEPT	25.58	19.24***
Adjusted R^2	0.70 F[685,1933]=9.90***	
Random effects model		
BSTD	-0.40	-3.22***
LOGCOWS	-1.46	-11.84***
PARLOR	0.06	0.32
OPERATOR_AGE	0.03	5.29***
EDUC_DUM	0.09	0.60
INTERCEPT	21.51	36.33***
Hausman Test value	28.37***	
Random effects model with year dummy variables		
BSTD	-0.31	-2.53**
LOGCOWS	-1.87	-12.63***
PARLOR	0.14	0.70
OPERATOR_AGE	0.02	3.62***
EDUC_DUM	0.11	0.67
INTERCEPT	23.90	30.83***
Hausman Test value	8.95	

**Statistically significant at ρ = 0.10.*
***Statistically significant at ρ = 0.05.*
****Statistically significant at ρ = 0.01.*

Conclusions

Using New York dairy farm business summary data over the nine-year period of 1994–2002, the impact of recombinant bovine somatotropin use on the cost of producing a hundredweight of milk was estimated. A total of 2,619 observations were used, representing 675 unique farms.

Self-selection was modeled using the Heckman (1979) two-step procedure, where adoption of rbST was first estimated and then used to calculate inverse Mills ratios to use as a variable in impact regressions. Both fixed and random effects models were estimated, but self-selection bias was not found to exist. Results were thus estimated and reported without modeling self-selection effects. The results imply that the use of rbST on these dairy farms reduces the cost of producing a hundredweight of milk somewhere between \$0.23 and \$0.52. For a 20,000 pound average production per cow, this would be a cost saving of \$46–104 per cow.

References

Butler, L.J. (1992). Economic evaluation of bST for onfarm use. In M.C. Hallberg (Ed.), *Bovine somatotropin and emerging issues: an assessment* (pp. 145-71). Boulder, CO: Westview Press.

Foltz, J., & Chang, H.H. (2002). The adoption and profitability of rbST on Connecticut dairy farms. *American Journal of Agricultural Economics, 84*, 1021-32.

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

Heckman, J. (1979). Sample selection bias as a specification error. *Econometrica*, *47*, 153-61.

Knoblauch, W.A., & Putnam, L.D. (1998). *Dairy farm management business summary, New York State, 1997*, (R.B. 98-06). Ithaca, NY: Cornell University Department of Agricultural, Managerial, and Resource Economics.

Marion, B.W., & Wills, R.L. (1990). A prospective assessment of the impacts of bovine somatotropin: a case study of Wisconsin. *American Journal of Agricultural Economics*, *72*, 326-36.

McBride, W.D., Short, S., & El-Osta, H. (2004). The adoption and impact of bovine somatotropin on U.S dairy farms. *Review of Agricultural Economics*, *26*, 472-88.

Ott, S.L., & Rendleman, C.M. (2000). Economic impacts associated with bovine somatotropin (BST) use based on survey of US dairy herds. *AgBioForum*, *3*(2&3), 173-80.

Stefanides, Z., & 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. (2001a). Efficiency and competitiveness of the small New York dairy farm. *Journal of Dairy Science*, *84*, 2573-76.

Tauer, L. (2001b). The estimated profit impact of recombinant bovine somatotropin on New York dairy farms for the years 1994 through 1997. *AgBioForum*, *4*(2), 115-123.

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

Acknowledgement

The author thanks William Tomek for comments.