AGRICULTURAL ECONOMICS

Journal of Student Papers

AMERICAN AGRICULTURAL ECONOMICS ASSOCIATION

Volume 6, No. 1
October 1988

IMPLICATIONS OF BOVINE SOMATOTROPIN ON THE VALUE OF FLUID MILK QUOTA IN ONTARIO

James Brown, University of Guelph, Guelph, Ontario, Canada

Abstract

The biotechnological production of recombinant bovine somatotropin (rbST) could have a tremendous impact on the North American dairy industries. In order to evaluate some of the potential effects of this science on the milk producers of Ontario, an econometric model was developed. The distortions caused by the dairy policies of this province were incorporated into the model.

The focus of the simulation was to predict the possible effect that rbST could have on the value of milk production quota in Ontario. The Ontario Milk Marketing Board (OMMB) has the legislated authority to set supply limits. The policies that the Board chooses to adopt will determine the eventual influence that this, and any, cost-reducing technological advance will have on quota values.

This study examines the range of values that may occur given various policy choices by the OMMB.

INTRODUCTION

Bovine somatotropin (bST) is a hormone produced naturally by cattle. Researchers have known for more than 50 years that this chemical compound can increase the production of milk (Becker, 1986). Scientists have used extracts of bST from pituitary glands of slaughter cattle to test the effectiveness of the hormone. Of course, large scale use is not feasible by this means. It has not been until this dawning age of biotechnology that commercial use of this science may be possible. A great deal of time and money has been invested by public and private research institutions to examine the production and effects of recombinant bovine somatotropin (rbST).

Daily injections of rbST have been demonstrated to be as effective as extracted bST (Bauman, et al., 1985; Macleod, 1986). Reports are that four of the major agri-chemical firms in Canada are working on sustained release implants which could be administered monthly, and expect the implants to be available for testing in 1988.

The author acknowledges and appreciates the many hours of assistance given by Dr. Ellen W. Goddard. Appreciation is also extended to Professor T. K. Warley who offered helpful comments and suggestions for this paper.

Progress in this direction is pointing toward the possible application of this new technology on the farm. Competitive mass production of rbST will probably make it an affordable input to milk production in Ontario. It is important to consider how this could affect the dairy industry in this province. This paper examines the implications that rbST could have on quota values for fluid milk in Ontario and quantifies the possible range over which quota values may vary.

BACKGROUND INFORMATION

A typical dairy farm in Ontario had over 200,000 dollars worth of quota in 1987 (Ontario Ministry of Agriculture and Food, 1987). This represented more than 30 percent of the total farm asset values. Understandably, the value of quota has become a very important issue for milk producers and they are eager to know about any factor that may influence quota values and, ultimately, their wealth.

Quotas are administered by the Ontario Milk Marketing Board (OMMB). This organization operates the supply management system and acts as a single buyer and seller of raw milk for the province. It uses its legislated authority to restrict the quantity sold to domestic processors in order to be fair for farmers. Farmers hold quota which allows them to market a certain quantity of milk to the Board. Because of this limitation on output, farmers must compete for the right to produce. Quota is auctioned through the Board monthly. A simple diagram can be used to illustrate how quota values are theoretically explained.

Figure 1 shows that quantities are restricted below the equilibrium supply, Q_E to the supply managed level of Q_{SM}. This generates price P_{SM}. The market equilibrium price, P_E, would have been lower and the price that farmers would have been willing to accept to supply the limited quantity would have been lower still at their marginal cost, MC_O. The cross-hatched area represents the excess returns for producing quantity Q_{SM} under supply management and, hence, the maximum amount farmers would be willing to pay for the quota which entitles them to those returns.

Research on the use of rbST suggests that milk production increases could be in the range of 20 percent to 40 percent (Bauman, et al., 1985; Burton, et al., 1987; Chalupa, et al., 1986). Some costs will be associated with the production of this extra milk: the rbST must be purchased and the cows will increase their feed consumption, but no capital expenditures would have to be made to utilize this technology. This adjustment in the cost of production will produce a new profit margin which, in turn, will change the value of quota. It would be helpful to know how much quota values would change should rbST be approved and adopted for use in milk production.

THE HYPOTHESIS

We would expect that the introduction of a cost-saving form of new technology would shift the producers' supply curve outward. Farmers would be willing to provide more milk at the same price as before because it would cost less to produce it. The way that this will affect quota values depends upon the pricing policy of the OMMB. If the Board chooses to keep supplies consistent with those in recent years, the price will remain relatively unchanged. This will increase the profit margin for producers using rbST and therefore, increase the amount they would be willing to pay for quota. They would naturally want to expand their production because of the profit they would be making. As well, they would be able to produce more milk in the same barn and with the same number of cows as they had before the introduction of rbST. Alternatively, the Board may elect to adjust supplies to maintain the same "fair" profit margin. This should cause quota values to remain constant.

Figure 2 illustrates the effects on quota values in a supply-managed market undergoing technological advances. The supply could be held at Q_{SM} and per-unit quota rents would increase from P_{SM}- MC_O to P_{SM} - MC_1[1] On the other hand, supply could be set at $Q_{SM}2$ such that the original per-unit quota rent P_{SM} - MC_O equals the new value $P_{SM}2$ - $MC^2{}_1$

ECONOMETRIC ANALYSIS

An econometric model, composed of estimated supply and demand curves for milk in Ontario, can be used to simulate the dairy industry and to examine the impact of rbST. The two scenarios to be examined with the model are: the OMMB may continue to restrict supply to the level that is currently maintained or it may adjust the quantity allowed on the market in order to keep quota values relatively constant.

The retail level demand for milk in Ontario was specified as a logarithmic expenditure function which incorporated a number of independent factors that economic theory suggests would be expected to contribute to the demand for fluid milk. The data were adjusted to a per capita basis by dividing by population. Relevant prices and income were deflated by the consumer price index (1981 = 100). Variables to account for trends in consumption between seasons and over the years were included, also. As a result, the variables used in the regression were:

- Ln(TEXP) - total milk expenditure in dollars (dependent variable)
- Ln(APCY) - adjusted price of fluid milk in Ontario, $/litre

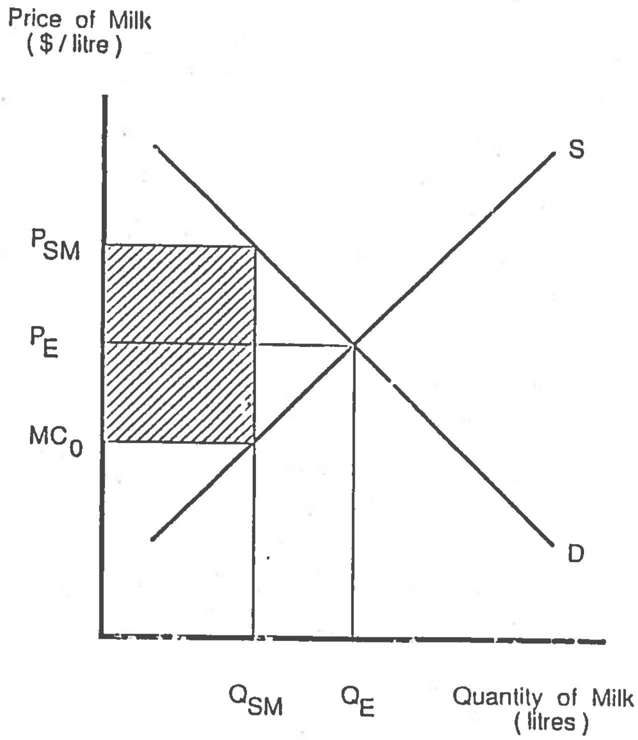

Figure 1. Diagrammatic Illustration of Quota Values

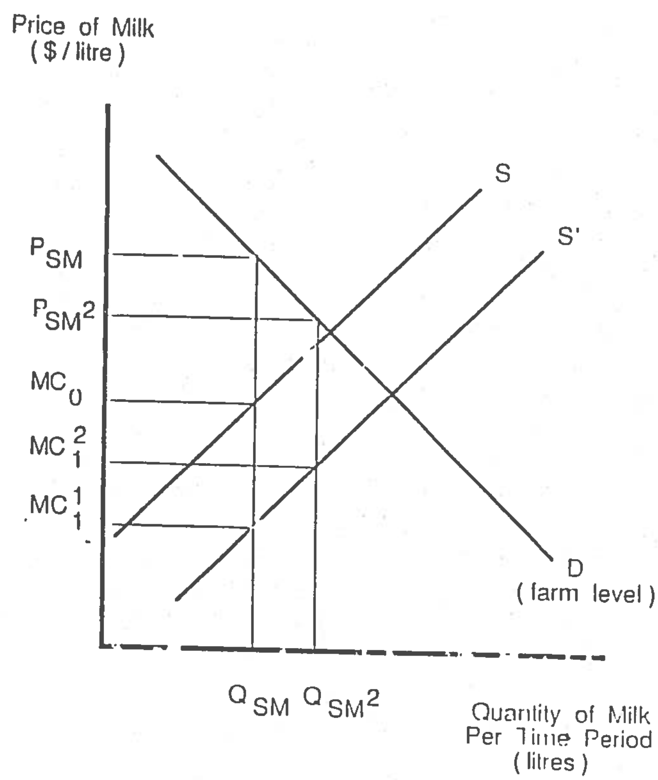

Figure 2. Quota Values in a Supply-Managed Market Undergoing Technological Advances

- Ln(APCY) - adjusted per capita disposable income in Ontario, $
- Ln(APA) - adjusted price of apple juice (an alternative beverage) in Ontario, $/litre
- DEM - proportion of Ontario's population under age 4
- TIME - time, to account for a trend through the years
- D1 to D3 - seasonal variables, to account for trends in consumption in the first, second, and third quarters of the year

Ln() denotes that the natural logarithm of the variable was taken.

The sign of the coefficient on the own price cannot be determined *a priori*; in a log-log equation it can be either negative (implying price elastic demand) or positive but less than one (implying price inelastic demand). If milk is a normal good the expected sign of the coefficient for income is positive. If apple juice is a substitute for milk, the expected sign on the coefficient for the price of apple juice is positive.

Quarterly data for the variables over a sample period from the fourth quarter of 1973 to the third quarter of 1984 were used for the regression. The coefficients and t-statistics for the regression are presented in Table 1.

Elasticities calculated from the data and results of the regression are shown in Table 2 and compared to those published in Hassan and Johnson's *Consumer Demand for Major Foods in Canada* and in Tomek and Robinson (page 69). Note that the cross price elasticity is calculated for apple juice alone while the figure from Hassan and Johnson is that for all beverages. This figure was not available in Tomek and Robinson.

The dairy industry in Ontario had been under supply management for about twenty years: this market intervention causes distortions, making the supply function unidentifiable from Ontario price and quantity data. The supply function was modeled using U.S. farm prices for fluid milk (adjusted to Canadian dollars per

Table 1. Estimated Demand Function for Fluid Milk in Ontario, 1973 to 1984.

Explanatory Variable	Coefficient	t-Statistic	Level of Significance	Elasticity
Constant	4.0606000	6.3987	99.5%	
Ln(APM)	0.8465300	8.5121	99.5%	-0.153
Ln(APCY)	0.4788200	1.5826	90.0%	0.479
Ln(APA)	0.1329500	-1.5284	90.0%	-0.133
DEM	0.1418500	-2.4843	99.0%	-0.142
TIME	0.0044697	-4.6396	99.5%	-0.004
D1	0.0623690	-2.2548	99.0%	-0.062
D2	0.0560910	-2.8845	99.5%	-0.056
D3	0.0328420	-2.3156	99.0%	-0.033

Dependent Variable:: Logarithm of Milk Expenditure in Dollars per Person

Adjusted R-squared:	0.838
Durbin-Watson:	1.495
F-statistic:	28.771

Table 2. A Comparison of Elasticities[a] of Demand for Milk

	Calculated Elasticity	Hassan and Johnson	Tomek and Robinson
Own price	-0.153	-0.4390	-0.35
Income	0.479	0.2056	0.20
Cross price	-0.133	0.00521	na

[a]Elasticities for a logarithmic expenditure function are the coefficients on all independent variables except own price. In this case, the price elasticity of demand for milk is calculated as follows:

$$\ln(TEXP) = a + b(\ln(APM))$$

Since $\ln(TEXP) = \ln(PCMD \times APM)$

Therefore, $\ln(PCMD) = a + b(\ln(APM)) - \ln(APM)$

$$\frac{\partial \ln(PCMD)}{\partial \ln(APM)} = b\frac{\ln(APM)}{\ln(APM)} - \frac{\ln(APM)}{\ln(APM)}$$

$$= b - 1$$

liter) as an estimate of the prices that would have been derived if the Ontario market were not under supply management. The greater size of the U.S. market and the fact that Ontario would trade dairy products if supply management did not exist are the basis for this assumption. It is recognized that the U.S. milk price is also affected by government programs in that market, but there is no reason to expect that U.S. Dairy programs would disappear if Ontario's supply management program did. An alternative approach to estimate the open market price would have been to subtract the inputed cost of quota rental from the observed prices, but quota was not always traded freely by auction and this introduces other distortions.

As with the demand equation, the quarterly data for the supply variables were adjusted by deflating by the consumer price index. The supply function was estimated over the same period as the demand function. The variables used were:

- AUSPM (t-1) - adjusted U.S. farm price of fluid milk, $/liter
- APC (t-1) - adjusted price of corn in Ontario, $/tonne
- QS (t-1) - lagged quantity of milk supplied (dependent variable), millions of litres
- D1 to D3 - seasonal variables, to account for trends in consumption in the first, second, and third quarters of the year

Some of the variables were lagged by one quarter (t-1) to incorporate the fact that it takes about three months to make a change in production in response to changes in market variables.

A priori, one would expect that price would be positively related to supply since farmers would be willing to sell more milk at higher prices. The price of corn would be expected to have the opposite effect - higher costs would make the farmer less willing to sell at the given price. The results of the supply regression are summarized in Table 3.

Table 3. Estimated Supply Function For Fluid Milk in Ontario, 1973 to 1984

Explanatory Variable	Coefficient	t-Statistic	Level of Significance	Elasticity
Constant	132.51000	4.4858	99.5%	
AUSPM (t-1)	59.68700	1.7719	95.0%	0.198
APC (t-1)	-0.12369	-3.7329	99.5%	-0.083
QA (t-1)	0.45476	3.8899	99.5%	
D1	-10.65400	-4.3344	99.0%	-0.011
D2	-9.09100	-3.6503	99.5%	-0.009
D3	-3.52480	-1.4800	90.0%	-0.004

Dependent Variable:: Quantity of Milk Supplied in Millions of Litres

Adjusted R-squared:	0.768
Durbin-Watson:	2.214
F-statistic:	24.701

The simulation combined the two equations and made adjustments for the fact that the demand function was estimated at the retail level while the supply function was based on farm-level prices. This was accomplished by incorporating a marketing margin which was assumed constant and set at 0.4117 dollars per litre - a measured margin in an arbitrarily selected period using Agriculture Canada data. The complete model had two equations, one identity, and three endogenous variables. Since production is fixed by quota, the three endogenous variables were the retail price generated in the market for a fixed production level converted to a farm level equivalent by the constant marketing margin and the price to producers which proxies the marginal cost of production. The difference between the two represents the static unit value of quota.

The base simulation performed very well. All of the major turning points over the estimation period were captured by the model. This established the confidence needed to use the model to simulate a shift in the supply curve.

The shift in supply was estimated by using price as a proxy for profit margin. Profit margin is not a direct component of the model but it will be the factor that motivates farmers to change their supply habits. In a conversation with Dr.

John Burton at the University of Guelph, he estimated that the first 10 percent of a potential 20 percent increase in milk revenues would be required to cover the costs of producing the extra milk. If we assume that this leads to an increase in profit represented by a 10 percent increase in price, we can approximate the supply response. The coefficient on price was 59.7 which means that a unit change in price will cause 59.7 unit changes in supply. The mean price over the sample period was 0.39462 dollars per litre in constant 1981 dollars. Ten percent of the mean price is 0.039462 dollars per litre. Therefore a 10 percent increase in price would generate an increase in supply of 0.038462 X 59.7 = 2.3559 million litres of milk per quarter or an increase of approximately 1 percent. Based on these calculations, the supply curve was shifted outward by increasing the constant in the function by a factor of 1.01.

RESULTS

The base simulation under supply management yielded a farm-level market price of 0.3946 dollars per litre and a quarterly supply of 235.85 million litres (see Table 4). The price that farmers would have been willing to accept for that supply (or the marginal cost of production) was 0.3610 dollars per litre. Therefore, the farmer was receiving 0.0336 dollars per litre above marginal costs of production - this translated into 0.0336 X 365 - 12.26 dollars per year of extra returns for every litre shipped daily. Since fluid milk quota entitles a producer to ship one litre each day for the life of the quota, the most he would have been willing to pay for the quota would have been the present value of the stream of extra returns. At a discount rate of 10 percent, that made quota worth $122.60 per litre. This figure represented the average value of quota over the simulation period, expressed in 1981 dollars. The actual price for quota in 1981 was approximately $100/litre. However, it doubled within a year after than so the actual average for the period would not be far from the $122.60 simulated.

Table 4. Summary of Simulation Results

	Base	Scenario 1[a]	Scenario 2[b]
Market Price	0.3946	0.3946	0.3745
Marginal cost	0.3610	0.3388	0.3409
Unit value of quota	0.0336	0.0558	0.0336
Net present value of quota	122.60	203.67	122.60

[a]Supply curve shifted outwatd and quantity allowed on the market was held constant.

[b]Supply curve shifted outward and quantity allowed on the market was increased to hold quota values constant.

When the effect of rbST was allowed to shift the supply outward, the price that farmers would have been willing to accept for the same quantity of milk dropped to 0.3388 dollars per litre. The price differential increased to 0.0558. Going through calculations similar to those above, the value of quota can be calculated to be $203.67/litre. This is an increase of 66 percent over the original value of quota.

If the Board wished to maintain the negotiated rate of return and, hence, constant quota values, it could allow supply to increase to just over 236 million litres per quarter.

CONCLUSIONS

The results indicate that the use of rbST could lead to as much as a 66 percent increase in quota values, depending on the policy followed by the OMMB. Although it would seem more logical to maintain a consistent or slightly improved profit margin, it is not difficult to imagine that the Board could allow most of the benefit of using rbST to be capitalized into quota values. The Board is controlled by many existing milk producers. If the adoption of this new technology is only gradual, there may be enough vocal farmers who are slow to change but still insist on their costs being covered in the calculation of the cost of production. The dairymen who do take advantage of rbST will be bidding up the price of quota as they attempt to extract larger profits out of the business. Once the value of quota has gone up, farmers would oppose any efforts by the Board to lower them. Indeed, the producers on the Board would probably not be willing to consider such policies because of the vested interests they have themselves. Once the extra profit has been capitalized and quota has changed hands for money, producers would insist on the retention of the $39 per hectolitre price (which would not be too high for those who paid the high price for quota).

FURTHER CONSIDERATIONS

Many factors can influence the market for milk given the introduction of rbST Consumers may perceive that the use of hormones in the production of milk makes it a health risk: milk may cease to be the wholesome food it has long been regarded. This could cause an inward shift in the demand curve which would eventually be translated into lower quota values. Perhaps more significant, the multilateral trade negotiations could affect the future of our supply management program. Quota values would tumble if our borders were opened to lower-prices dairy product imports. In fact, even the suspicion of this possibility could put pressure on quota values (and politicians).

Because quota values are set through an auction, they are a proxy for all of the fears and hopes and expectations of the buyers and sellers in that market. Attempting to incorporate all of these components into a single econometric model is unreasonable. We must continue to make short-term forecasts and recommendations based on the circumstances at the time in order to best advise our dairy industry and policy-makers.

REFERENCES

Agriculture Canada. *Dairy Market Reviews*. Ottawa, Various issues.

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

Becker, Geoffrey and Sarah Taylor *Bovine Growth Hormone (Somatotropin): Agricultural and Regulatory Issues*. Congressional Research Service, The Library of Congress, Washington, 1986.

Burton, J.H. B.W. McBride, K. Bateman, G.K. Macleod and R.G. Eggert. "Recombinant Bovine Somatotropin: Effects on Production and Reproduction in Lactating Cows." *Journal of Dairy Science,* (Supplement 1), 70(1987):175.

Chalupa, W., B. Vecchiarelli, P. Schneider and R.G. Eggert. "Long-Term Responses of Lactating Cows to Daily Injection of Recombinant Somatotropin." *Journal of Dairy Science*. (Supplement 1), 69(1986):151.

Hassan, Z. A. and S. R. Johnson. *Consumer Demand For Major Foods in Canada*. Economic Branch, Agriculture Canada, Ottawa, 1976.

Macleod, Gordon. *Recent Developments in Bovine Growth Hormone*. Presentation at Kemptville Dairy Day, February 10, 1986.

Ontario Ministry of Agriculture and Food. *Agricultural Statistics for Ontario*. Toronto, Various issues.

Ontario Ministry of Agriculture and Food. *Ontario Farm Management Analysis Project*. Toronto, 1988.

Statistics Canada. *Consumer Prices and Price Indexes*. Bulls. 62-010, Ottawa, various issues.

Tomek, W. G., and K. L. Robinson. *Agricultural Product Prices*. Cornell University Press, Ithaca, New York, 1981.

United States Department of Agriculture. *Dairy Situation and Outlook Report*. Washington, D.C., various issues.