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THE VALUE OF SEGMENTING THE MILK MARKET INTO bST-PRODUCED AND NON-bST-PRODUCED MILK

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Abstract

This paper discusses the value to milk producers and consumers of segmenting the milk market into bST-produced milk and non-bST-produced milk markets, versus losing milk consumption from consumers who will not consume bST-produced milk. Results indicate that both bST-using producers and non-bST-using producers benefit from a segmented market. Even if market loss does not occur, segmenting the market benefits all producers. Non-bST consuming consumers benefit from the availability of non-bST milk, but consumers who are indifferent to the use of bST pay a slightly higher milk price in a segmented market.

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Introduction

The value of product differentiation to producers is well known in industrial organization and in agricultural marketing where market orders operate (Tirole). In these instances, a firm or a coalition of producers are able to differentiate the market for a product or commodity such that two separate demands exist, with one demand being more inelastic. The result is the enhancement of revenue with often minimal cost of differentiation.

Is product differentiation of value when a coalition of producers cannot be formed, such that the differentiation partitions the set of producers into two groups, with each group only supplying one of the two markets? This paper looks at that issue in the context of bST (bovine Somatotropin) and non-bST-produced milk, but the issue applies to any product where there is a real or perceived difference in quality. Other examples include organic and nonorganic produce, range-fed versus confinement-produced chickens or eggs, and identity-preserved grains.

Milk Demand

It is assumed that the introduction of bST-produced milk on the market segments consumers into those who will buy bST-produced milk as if it were regular milk and those who will only consume non-bST-produced milk. This is illustrated in Figure 1 where the demand curve for milk before the introduction of bST is partitioned into non-

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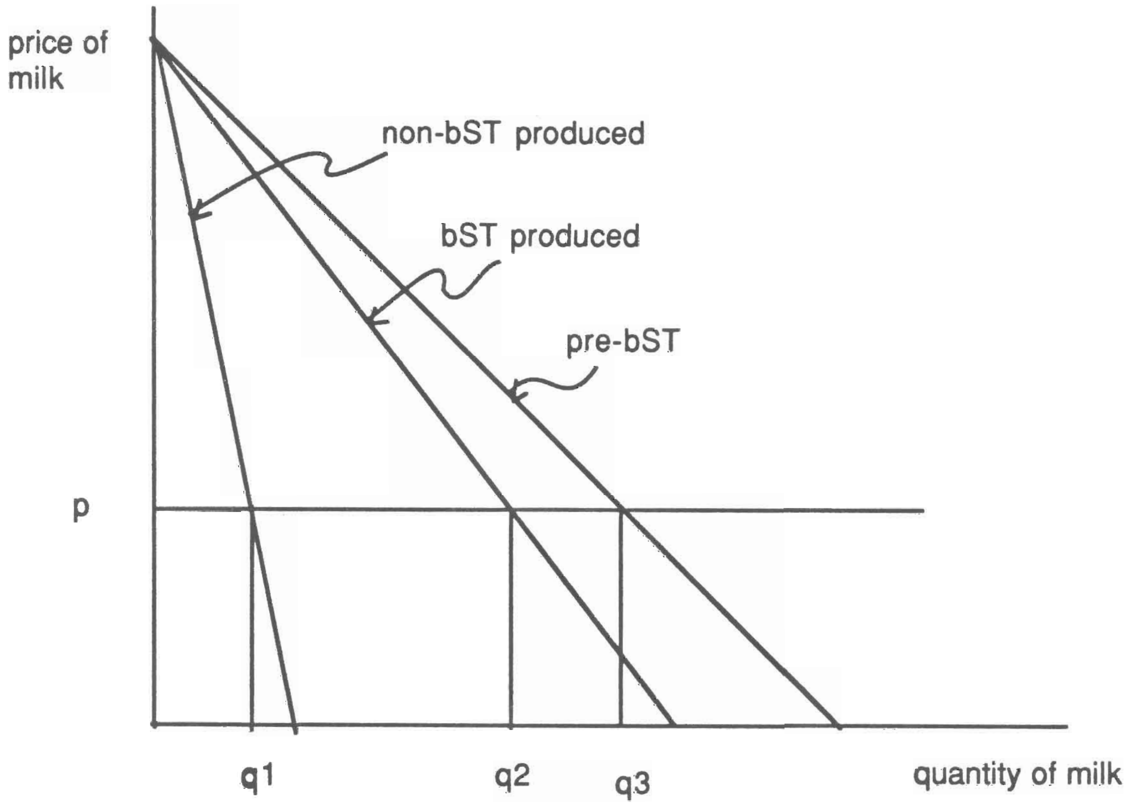
Figure 1: Market Segmentation of bST and non–bST Produced Milk



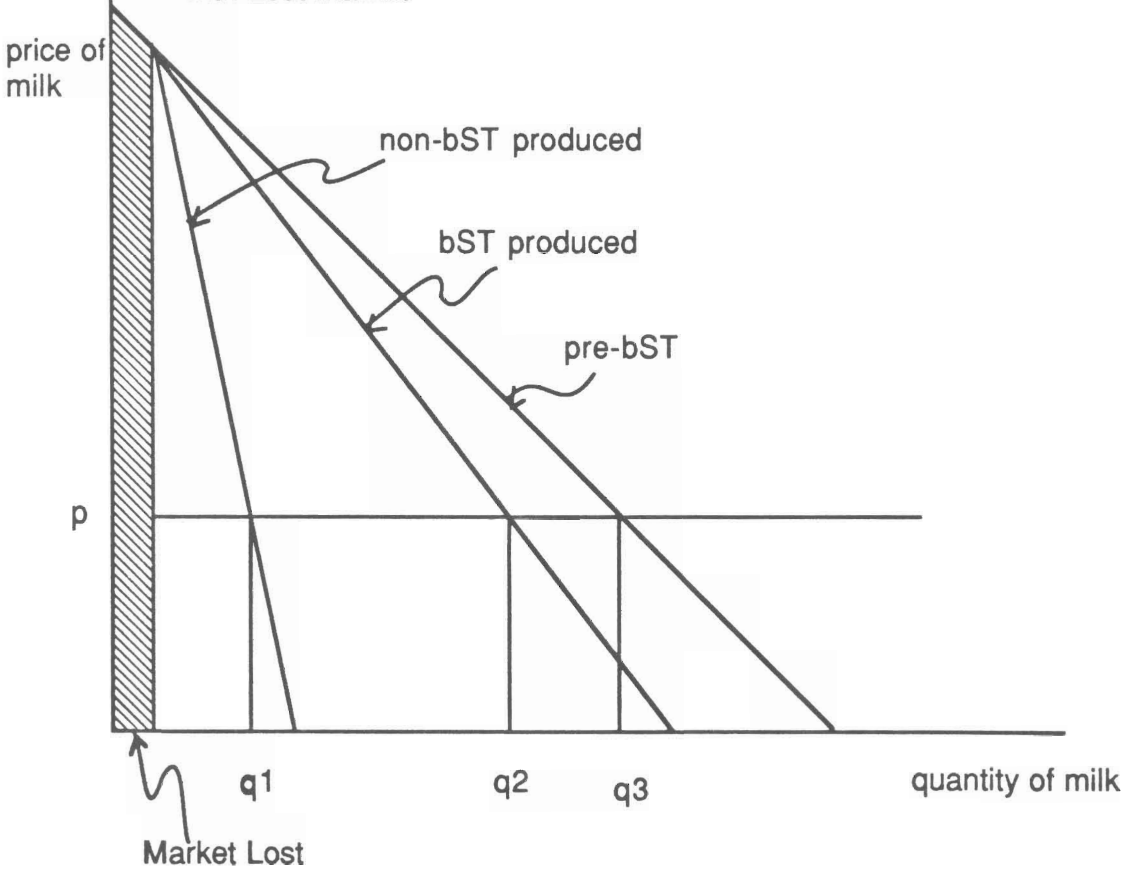
bST and bST milk. It is assumed that at any price the quantity of non-bST milk and bST milk demanded equals the quantity of milk demanded before the introduction of bST. In Figure 1, $q_1 + q_2 = q_3$. Any difference in total milk consumption post-bST, compared to pre-bST, would only be due to the price effects of moving up or down the segmented demand curves.

Partitioning the milk market into bST and non-bST milk requires labeling milk so that consumers can identify the differentiated product. At a minimum, this necessitates identifying the non-bST-produced milk with a label, since the transference of demand is caused by those searching for non-bST-produced milk. The legality and economics of labeling are separate issues discussed by Caswell and Padberg.

The demand functions shown in Figure 1 are also farm gate, rather than final demand curves, such that marketing margins are removed. Partitioning the demand function into two segments that sum to the original function implies that marketing margins are not altered by market segmentation. However, labeling and maintaining two separate milk markets may increase marketing costs and margins, such that the two segmented markets do not run to the original nondifferentiated market. Marketing margins are discussed by Gardner. The impact of changing marketing margins on farm prices is discussed by Fisher.

Some survey studies have shown that some consumers will stop or reduce their consumption of milk if bST is introduced (Kaiser, Scherer and Barbano; Preston, McGuirck and Jones). However, since these consumers were willing to consume milk before bST, they should be willing to drink non-bST milk. Any reduction in milk consumed (besides price effects) would be due to protest or lack of confidence that any milk labeled as non-bST is indeed non-bST produced. This scenario can be illustrated in Figure 2 by a horizontal shift in the vertical axis of the demand schedule and then the segmentation of the truncated demand schedule into non-bST and bST-produced milk. It is

Figure 2: Market Segmentation of bST and non-bST Produced Milk with Lost Market



clear in this case that with the rightward shift in the quantity origin that $q_1 + q_2 < q_3$, such that at any price less milk will be consumed after bST is introduced.

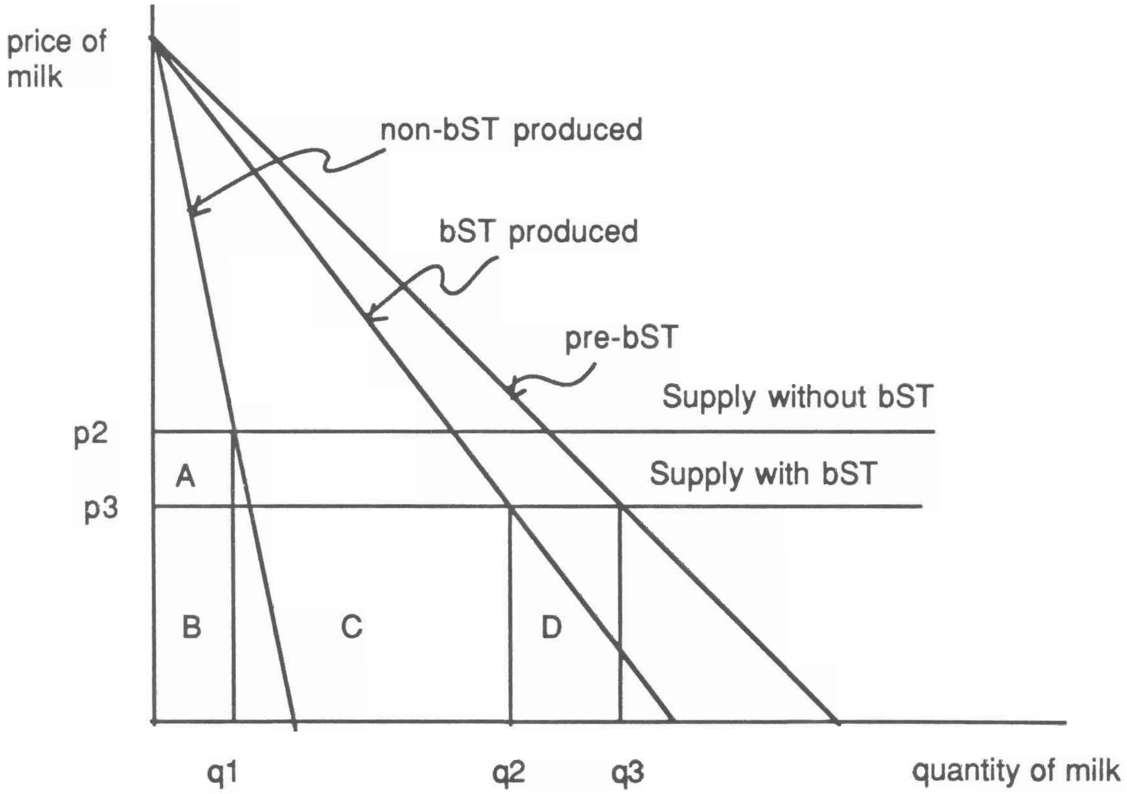
The Constant Cost Industry

In order to determine the welfare effects of segmenting the milk market, it is necessary to know the milk supply functions without the introduction of bST, with the use of bST, and without the use of bST. The simplest case would be if the dairy industry is a constant cost industry. That scenario is represented in Figure 3. The supply curve with no bST is shown as a perfectly horizontal line since milk can be produced at a constant price. This does not preclude an increasing cost curve for individual producers, but that additional producers can enter or leave the industry with the same minimum cost as other producers. That minimum cost includes the necessary return to unpaid labor, management, and equity to keep those resources in dairy production. Since the use of bST reduces the unit cost of production, the supply curve for bST users is a parallel downward shift in the non-bST supply curve. Since producers can freely enter or leave the industry, the supply curve for non-bST users is identical to the supply curve before the availability of bST.

With no market differential, when bST is introduced, the market equilibrium is price ρ_3 and quantity q_3. Total receipts to the industry is area B + C + D. Since this also entails the cost of production, there is no producer surplus earned. Consumer surplus is increased, however.

If the market is differentiated, the receipts of the bST users are B + C, and the receipts of the non-bST users are A + B, for total receipts to the sector of A + 2B + C. These receipts are greater than without market differentiation with inelastic demand since A + B > D. However, since we still have a constant cost industry, there is no producer surplus. Although total receipts are increased with market differentiation, the total quantity of milk produced is lower since $q_3 > q_1 + q_2$. The higher price of ρ_2 for non-bST-

Figure 3: Constant Cost Industry



produced milk reduces total demand for all milk but increases revenue. The larger revenue is necessary to offset the greater costs of producing some milk without bST than producing all milk with bST. Since less quantity is produced, fewer dairy producers are necessary if farmers have homogeneous cost structures, which is typically assumed with a constant cost industry. Fewer farmers would probably be viewed as a negative development by any organization of farmers.

An Increasing Cost Industry

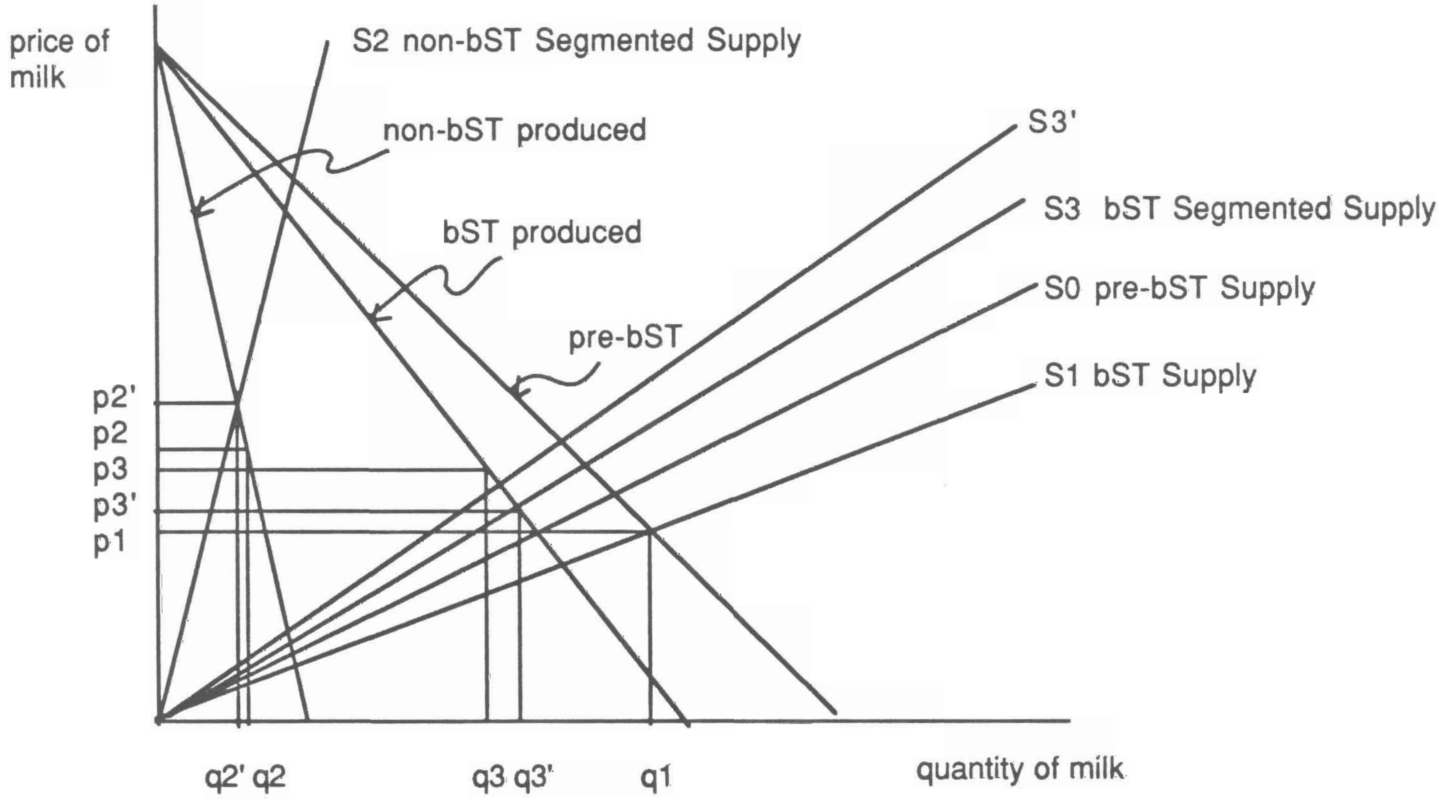
Although some dairy facilities can be replicated with identical cost structure, most production can only be expanded by bringing into production lower productive land and other resources. The implication is an increasing cost industry where the aggregate supply curve is upward sloping.

The scenarios of an increasing cost dairy industry is illustrated in Figure 4. That figure shows the supply curve before the introduction of bST as S_0. That curve originates at the origin and increases linearly. That is a specific representation to simplify exposition. An increasing cost industry can also be represented by a nonlinear, increasing curve that does not intersect the origin.

The introduction of bST and complete adoption will shift the supply curve from S_0 to S_1. This is a rotation or divergent shift of w percent. A rotational shift is commonly used for technological change, but it is not universal. Parallel or convergent shifts have been proposed for technology change, and alters the economic analysis (Wise).

The introduction of bST and complete use leads to an equilibrium price of ρ_1 and quantity of q_1. If the milk market is segmented into bST and non-bST components, the supply curves become S_2 for non-bST use and S_3 for bST use. These curves are generated by partitioning the pre-bST supply curve, S_0, into S_2 and S_3', such that $S_2 + S_3' = S_0$, and then by rotating S_3' by w percent to produce S_3. Thus, $S_0 < S_2 + S_3 < S_1$ at any price

Figure 4: bST Segmentation in an Increasing Cost Industry



ρ. With the demand curve for milk segmented, the equilibrium conditions are ρ_2' and q_2' for non-bST milk and ρ_3' and q_3' for bST milk.

However, the above segmentation is only valid if production arbitrage does not exist between the two markets. Non-bST users may not be able to move into the bST users group because they are not able to generate the bST yields, but bST users could stop using (or not use) bST if the price-spread between non-bST and bST milk became greater than the cost decrease from using bST.

A possible arbitrage is shown by movement of the non-bST market to ρ_2 and q_2 and the bST market to ρ_3 and q_3. It is assumed that $\rho_2 - \rho_3$ is the cost advantage of using bST. Each quantity of milk moved into the non-bST market reduces the quantity of milk in the bST market by 100 plus w percent.

The model illustrated in Figure 4 demonstrates that segmenting the milk market not only produces a higher milk price for non-bST users but also for bST users, although the total quantity of milk produced by both groups is less than if the market is not segmented. Producer surplus changes is dependent upon the elasticities of demand and supply. Consumers who are indifferent to the use of bST pay a higher price than if the market were not segmented. Consumers who refuse to drink bST-produced milk are better off at any price with a differentiated market since they then have non-bST milk to consume.

Applications

To quantify the changes shown in Figure 4 and to determine the ambiguous changes in producer surplus, numerical applications were computed using various demand and supply elasticities. A demand elasticity for milk of approximately -.3 and lower is common in the literature (Kaiser, Streeter and Liu). The range of estimated supply elasticities is much greater. Blayney and Mittelhammer estimated an elasticity of .89, but Chavas, Kraus and Jesse report elasticities over 2.0, and estimates as low as .29 are common from adjustment cost models (Weersink). The 1986-1990 national average price of milk was \$12.92 per cwt., and 149.42 billion pounds were consumed. Given that information and a demand elasticity of milk of -.3 and a supply elasticity of 1.0, linear demand and supply functions were constructed. The demand function for milk is P = 55.9867 - .2882Q. The supply function for milk is P = .0865Q.

In a review of the consumer surveys to bST milk, Smith and Warland conclude that 11.3 percent of respondents would stop drinking milk produced using bST. (A small percentage would also reduce their consumption.) Thus, the market demand was partitioned into 11.3 percent non-bST and 88.7 percent bST milk at every price. That produced a demand function for non-bST-produced milk of P_N = 55.9867 - 2.550Q_N and for other milk (bST) of P_B = 55.9867 - .3249Q_B. The demand function for milk if 11.3 percent of the market is simply lost is 51.1201 - .2882Q.

bST impact studies have used various yield increases (Fallert et al.). I elected to use a bST yield increase of 8 percent and a cost reduction of 4.4 percent. The supply function for bST-produced milk becomes P_B = .07958Q_B.

Using these values, the model illustrated by Figure 4 was empirically solved with and without a segmented market. Appendix A contains a listing of the GAUSS program used to solve for equilibrium price and quantity values and to calculate producer and consumer surpluses. The results are summarized in Table 1. Before bST, the price of milk is \$12.92 per cwt., and the quantity of milk produced is 149.42 billion pounds. Producer surplus is 965.25 units; consumer surplus is 3,217.51 units. The introduction of bST, complete adoption and a nonsegmented milk market produces ρ_1 = \$12.11 per cwt. and q_1 = 152.23 billion pounds. Producer surplus is reduced to 921.75, and consumer surplus is increased to 3,339.68.

Segmenting the market with arbitrage produces ρ_3 = \$12.14 and q_3 = 134.93 for the bST-produced milk, with producer surplus of 819.08, and ρ_2 = 12.67 and q_2 = 16.98

Table 1. Impact of bST-Produced Milk on the Milk Market

	Price ($/cwt.)	Quantity (bill. lbs.)	Producer surplus	Consumer surplus
		--- $E_D = -.3$	$E_S = 1.00$ ---	
Before bST	12.92	149.42	965	3218
After bST	12.11	152.23	922	3340
Market loss	11.06	139.00	768	2784
Market segmentation				
Non-bST	12.67	16.98	108	368
bST	12.14	134.93	819	2958
Total	12.20	151.92	927	3326
		--- $E_D = -.2$	$E_S = 1.00$ ---	
Before bST	12.92	149.42	965	4826
After bST	12.05	151.44	912	4958
Market loss	10.91	137.18	748	4068
Market segmentation				
Non-bST	12.62	16.96	107	551
bST	12.08	134.25	811	4392
Total	12.14	151.21	918	4943
		--- $E_D = -.3$	$E_S = 2.00$ ---	
Before bST	12.92	149.42	483	3218
After bST	12.47	151.00	453	3286
Market loss	11.88	136.16	369	2672
Market segmentation				
Non-bST	13.00	16.85	55	362
bST	12.46	133.96	402	2916
Total	12.52	150.82	457	3278
		--- $E_D = -.3$	$E_S = .25$ ---	
Before bST	12.92	149.42	1689	3218
After bST	10.95	156.24	1523	3518
Market loss	8.40	148.21	1134	3166
Market segmentation				
Non-bST	11.62	17.40	179	386
bST	11.13	138.05	1365	3097
Total	11.18	155.45	1544	3482

for the non-bST-produced milk with producer surplus of 107.61. This is a total producer surplus of 926.70, which is larger than the producer surplus with a nonsegmented market. The bST users also receive a price that is $.03 higher than if the market is not segmented. The average price received by all producers is $12.20, with total output of 151.92 billion pounds.

In contrast, if, instead of segmenting the market, 11.3 percent of the demand is lost, the impact on producers is significant. The price of milk falls to $11.06 and only 139 billion pounds are consumed. Producer surplus falls to 768.47. Although milk consumers buy milk at a much lower price, the exodus of milk consumers because of bST reduces consumer surplus to 2,784.33.

Table 1 also summarizes results if the demand elasticity is -.2 rather than -.3, and then if the supply elasticity is 2.0 and .25 rather than 1.0. The direction of the changes are similar to the first example, although the magnitudes of the changes are different.

Conclusions

Using a demand elasticity of -.3 and a supply elasticity of 1.0, the introduction of an 8 percent yield-increasing bST technology lowers equilibrium milk price by 6.2 percent and increases output by 1.9 percent. Since demand is inelastic, producer surplus is decreased.

If some consumers will not buy milk produced with bST, the opportunity to segment the market into bST- and non-bST-produced milk benefits all producers since both bST users and nonusers receive a higher milk price than if the market were nonsegmented. Their producer surplus is higher with a segmented market, but it is still lower than if bST were not introduced. This assumes that some consumers do not stop buying milk altogether. If, instead of segmenting the market, the consumers who do not wish to consume bST-produced milk simply stop buying milk, the impact on producers is significant, with a much lower milk price and producer surplus.

This analysis assumes a national milk market, although regional markets with integration exist in the U.S. The marketing costs of segmenting the milk market was assumed identical to a single market. However, the marketing system must bear the cost of keeping bST- and non-bST-produced milk differentiated. Those costs and how they are absorbed need to be investigated. Large costs may reduce the benefits shown here. The permanence of the demand differentiation is another unknown. As time passes, non-bST milk drinkers may migrate to bST milk consumption if they become convinced that bST-produced milk is healthy to drink.

Finally, the role of marketing orders or government support programs in a segmented market were not incorporated into the analysis. Most milk in the U.S. is sold in marketing orders where producers receive a blended milk price based upon the disposition of milk within their order rather than the use of their own specific milk to the fluid or processed market. In addition, a floor is placed on milk prices by government's purchase of milk products. How market order and support programs would operate in a segmented milk market needs to be explored if a segmented market is likely.

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APPENDIX A

```
/* >>===> BST 4389 6-4-92 1:04pm Page 1 */

/* This model solves for the equilibrium prices and quantities */
/* of a milk market segmented into a non-bST market and a bST */
/* market with abritrage of production from bST to non-bST */
/* It is written in GAUSS-386 2.2, Aptech Systems, Inc. */

library nlsys;
#include nlsys.ext;
nlset;

eld=-.30;  /* demand elasticity (negative)  */
els= 1.;  /* supply elasticity  */
p=12.92;  /* equil. price before bst  */
q=149.42;  /* equil. quantity before bst  */
loss=.113;  /* segment who will not drink bst milk  */
yield=.08;  /* milk yeild increase from bst  */
cost=.044;  /* cost advantage of using bst  */
demcon=p-p/eld;    /* intercept of demand curve */
demslope=p/(eld*q);  /* slope of demand curve */
supcon=p-p/els;      /* intercept of supply curve */
supslope=p/(els*q);  /* slope of supply curve */
demloss = demcon+(q*loss*demslope); /* intercept of demand curve with loss */

proc gsys(y);
local g1,g2;
/* demand curve for all milk, y[1] is quan., y[2] is price  */
g1= demcon+demslope*y[1]-y[2];
/* supply curve for milk produced all with bst      */
g2= supcon+supslope*(1-yield)*y[1]-y[2];
retp(g1|g2);
endp;

proc hsys(z);
local h1,h2;
/* demand curve lossing some of the milk market, z[1] is quan., z[2] is price */
h1 = demloss+demslope*z[1]-z[2];
/* supply curve for bST milk  */
h2 = supcon+supslope*(1-yield)*z[1]-z[2];
retp(h1|h2);
endp;

proc fsys(x);
local f1,f2,f3,f4,f5;
/* demand curve for bst milk, x[1] is quantity, x[2] is price */
f1 = demcon+(demslope/(1-loss))*x[1]-x[2];
/* demand curve for non-bst milk, x[3] is quan. x[4] is price */
f2 = demcon+(demslope/loss)*x[3]-x[4];
/* price of bst milk lower by cost of production */
f3 = x[4]-(1+cost)*x[2];
/* supply curve for bst produced milk weighted by x[5] */
f4 = supcon+(1-yield)*supslope*x[1]/(1-x[5])-x[2];
/* supply curve for non-bst produced milk weighted by x[5] */
f5 = supcon+supslope*x[3]/x[5]-x[4];
retp(f1|f2|f3|f4|f5);
endp;

y0 = { 140, 13 };
x0 = { 140, 13, 10, 14, .1 };
```

```
/* >>---> BST 4389 6-4-92 1:04pm Page 2 */

output file = bstseg.out reset;

{ y,g,r,scode } = nlprt(nlsys(&gsys,y0));
nlset;
{ z,h,e,dcode } = nlprt(nlsys(&hsys,y0));
nlset;
{ x,f,j,tcode } = nlprt(nlsys(&fsys,x0));

/* consumer surplus before bst */
csb = (demcon-p)*q/2;
/* producer surplus before bst */
if supcon >= 0;
psb = (p-supcon)*q/2;
else;
psb = (p-supcon)*q/2-((q/(p-supcon))*(-supcon))*(-supcon/2);
endif;

/* consumer surplus after bst before market segmentation */
csa = (demcon-y[2])*y[1]/2;
/* producer surplus after bst before market segmentation */
if supcon >= 0;
psa = (y[2]-supcon)*y[1]/2;
else;
psa = ((y[2]-supcon)*y[1]/2)-((y[1]/(y[2]-supcon))*(-supcon)*(-supcon/2));
endif;

/* consumer surplus after market loss */
csloss = (demloss-z[2])*z[1]/2;
/* producer surplus after market loss */
if supcon >= 0;
 psloss = (z[2]-supcon)*z[1]/2;
else;
 psloss = ((z[2]-supcon)*z[1]/2)-((z[1]/(z[2]-supcon))*(-supcon)*(-supcon/2));
endif;

/* consumer surplus with bst market segmentation, no bst first */
csan = (demcon-x[4])*x[3]/2;
csab = (demcon-x[2])*x[1]/2;
csat = csan+csab;
/* producer surplus with market segmentaion, first no bst users */
if supcon >= 0;
psan = (x[4]-supcon)*x[3]/2;
else;
psan = (x[4]-supcon)*x[3]/2-((x[3]/(x[4]-supcon))*(-supcon)*(-supcon/2));
endif;
if supcon >= 0;
psab = (x[2]-supcon)*x[1]/2;
else;
psab = (x[2]-supcon)*x[1]/2-((x[1]/(x[2]-supcon))*(-supcon)*(-supcon/2));
endif;
psat=psan+psab;

format /RD 15,2;
lprint "            " "          Price" "           Quantity"
"         Prod. Surplus"  "  Cons. Surplus" ;
lprint "                      ------------------------------------------------" ;
lprint "Before bst "  p q psb csb;
lprint "After bst  " y[2] y[1] psa csa;
```

```
lprint "Market loss" z[2] z[1] psloss csloss;
lprint "Market segmentation";
lprint " No-bST    " x[4] x[3] psan csan;
lprint "    bST    " x[2] x[1] psab csab;
totalq = x[1]+x[3];
weighedp = (x[4]*x[3]+x[2]*x[1])/totalq;
lprint " Total     " weighedp totalq psat csat;
lprint "---------------------------------------------------------------------" ;
format /RD 12,4;
lprint "demand elasticity  " eld;
lprint "supply elasticity  " els;
lprint "bST yield increase " yield;
lprint "bST cost advantage " cost;
lprint "proportion no-bST  " loss;
lprint ;

output off;
```

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