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Expected Economic Effects of BST in The Netherlands

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Abstract

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The calculated profitability of using Bovine Somatotropin (BST) on typical dairy farms in The Netherlands ranges from Dfl.160 to 300 per cow per year, assuming 1985 prices and circumstances, and ignoring the costs of BST. A 20% increase in milk production and no change of the feed/milk relation were used for the calculations. BST is more profitable on intensive farms or on farms with more opportunities for alternative uses of land, buildings and labour. The quota system, however, leads to a considerable reduction of profitability.

At a national level, and with an unchanged milk price, a 28% adoption rate of BST would increase national income about Dfl.120 million. However, the cost of BST or any decrease in milk price could reduce this amount, even to below zero. It is apparent that some dairy farmers who apply BST will earn more income whereas others will lose income.

Introduction

New technology is continuously being introduced into agriculture. Some of these innovations take a long time to be adopted, especially if high investments are necessary; others are rapidly assimilated. Often, the effects of innovations are studied after they have been implemented for some time (Griliches, 1957; Kennedy and Thirlwall, 1972). This makes it much easier to handle information like adoption rates, differences in costs and returns, etc. However, for farms and indeed for society, it is much more relevant to have advance knowledge of the probable economic effects of new techniques.

In this article the economic repercussions of the application of Bovine Somatotropin (BST) for dairy farms in The Netherlands will be investigated.

Dfl. 1.00 = US\$0.30 (1985) = US\$0.50 (1988).

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The central issue is profitability at farm level, but the economic effects of BST at a national level will also be evaluated, with specific reference only to The Netherlands.

BST, a naturally occurring protein produced in the pituitary gland of cattle, is one factor regulating the volume of milk production. Trials have shown that daily injection of supplemental BST in lactating dairy cows significantly boosts milk production. Kalter et al. (1985) report an increase of from 15 to 40% during the last 215 days of the lactation cycle.

Individual farms' circumstances vary, leading to important differences in the profitability of BST at farm level. Therefore, for decision-making the total set of dairy farms will have to be grouped into relevant types. Of course, the costs and revenues of individual farms within one group will not necessarily be the same. However, average results per type of farm are a good indication of individual reactions.

The application of BST at farm level will have important repercussions for the total agricultural sector. If input levels are decreased, resources that would otherwise be used in dairy farming become available. Given a quota system for the dairy sector, only the shift of the cost function for milk and the side-effects for other products are of interest. Unlike an open-market situation (see Kalter et al., 1985), the total quantity of milk, and therefore also the effect on the demand side of the dairy market, are of no importance. However, this does not imply that the acceptability of BST for the consumer, and therefore a possible shift in the demand for dairy products, can be neglected.

This article starts by discussing the methodology used in the study. After giving an overview of the structure of dairy farming in The Netherlands, the effects of BST at farm level are analyzed. A consistent framework for determining the effects of BST at sector level is developed. In the last section of this paper the results of sensitivity analysis are discussed, together with some relevant issues concerning the application of BST in the future.

1. Methodology

1.1 Background from economic theory

When analyzing a new technique, first the elements of the new technique should be compared with the old methods. The main characteristic of BST is the increase of milk output; this is accompanied by the need for more feed input.

In Fig. 1 we start with production function (1). The short-term optimal feed input level (F_1) can be derived from the price relation (p) between feed and milk. Starting from the original input/output function (1), BST can only increase the production per cow, but with the same conversion of feed input to milk output (2). A second possibility would be an improvement of this con-

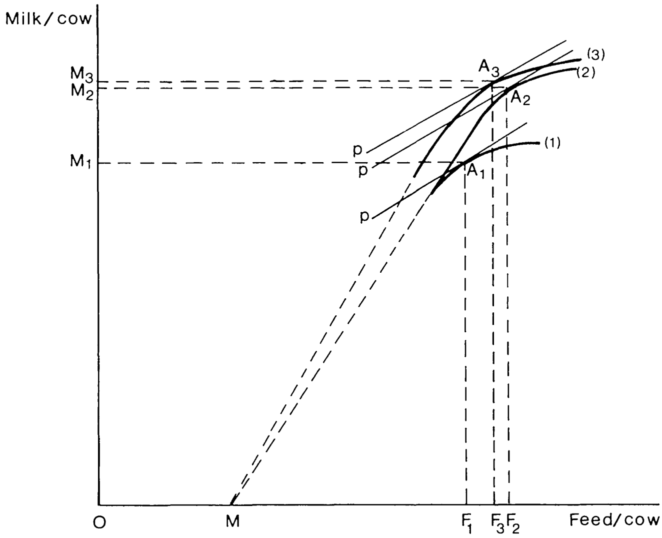

Fig. 1. Relation between feed input and milk production per cow[1] (1) without BST; (2) with BST, but no change of the marginal input/output relation; (3) with BST and change of input/output relation.

version (3). In both cases OM is the calculated maintenance feed. In situation (2) short-term optimal feed input (F_2) will certainly be higher than F_1. In situation (3) the position of F_3 depends on the shift in the input/output relation in comparison with the increase of potential milk yield.

Because there are no clear indications of the conversion rate improving in the long term (Buckwell and Morgan, 1987), we will start from line (2). This implies that:

- feed input for maintenance remains constant;
- relation between additional input and additional output remains constant;
- a particular cow can attain a higher level of milk output with a higher level of feed input.

However, to arrive at A_2 instead of A_1 the particular cow needs: (a) BST, (b) more feed input, perhaps also of better quality; also, (c) the expected number of productive lactations may decrease, veterinary costs may increase, etc.

Cost functions were derived from the partial input/output relation (Fig. 2). Here the functions MFC and AFC represent marginal feed costs and average

[1] The input/output relation between feed input and milk output is still a matter of controversy (Lenkeit et al., 1969/1971; Van Es and Nijkamp, 1969; Dijkstra, 1978; Heady and Bhide, 1983). However, we operate with a nearly linear relation up to certain level and a rather strong curve away at a high input level. Feed input has been defined as the availability of a relevant quality of feed, measured in Feed Equivalent Milk Units. Only part of the total curve can be considered as the relevant partial production function.

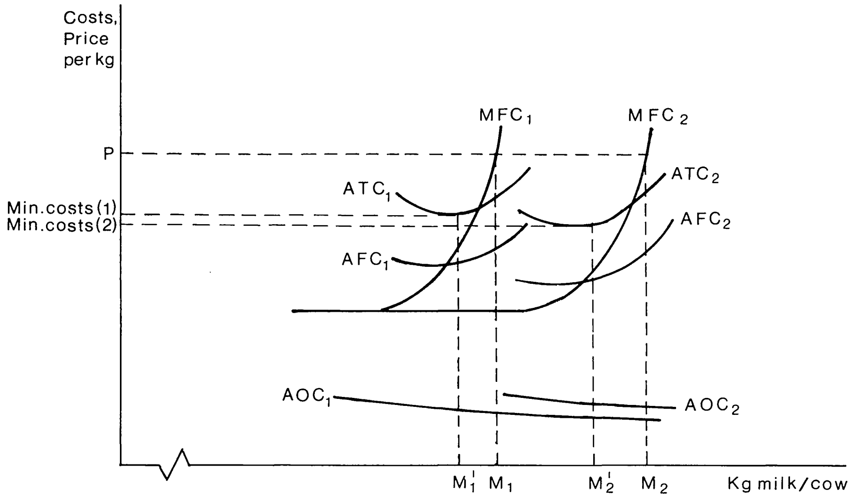

Fig. 2. Relation between production per cow and average and marginal costs per unit of milk: (1) without BST; (2) with BST.

feed costs per cow. AFC includes maintenance feed. Without a quota system, optimal milk production is M_1 (without BST) and M_2 (with BST), respectively[1]. With a quota system, optimal milk production per cow is where average total costs are at a minimum level. Average total costs (ATC) are the sum of AFC and average other costs (AOC). The minimum cost level in situation (2) compared with (1) depends on the difference between AOC_2 and AOC_1, where AOC_2 includes the cost of BST. Under a quota system the total cost difference per farm equals (Min. costs_2 − Min. costs_1) × total quota. Without a quota system the total quantity of milk can be increased. With unchanged input and output prices this implies an additional income effect.[2]

However, decisions in farming will not be taken for cows only but mostly with respect to the total farm. Figure 3 illustrates a typical situation for a specialized dairy farm. Here marginal production costs (1) decrease slightly over Oq_1, but at production level q_1 domestic roughage from the farm is sufficient. Increasing production implies buying in additional roughage and concentrates.[3]. Above production level q_2, the capacity of the farm is not sufficient (buildings, etc.) and new investments induce higher production costs[4].

Applying BST at farm level gives a new cost function: (2) (represented here

[1] Here we drop other variable costs per unit of milk from the analysis. Including these costs would imply a marginal cost curve above MFC.

[2] Decisions of individual farmers, however, will influence prices of feed input and other inputs. Therefore, in reality, the income effect of BST could be even larger under a quota system.

[3] Decreasing marginal costs of milk over particular trajectories originate from e.g. a better use of machinery capacity, price reductions for larger input quantities, etc.

[4] Whereas here only two steps are introduced, more steps could be relevant.

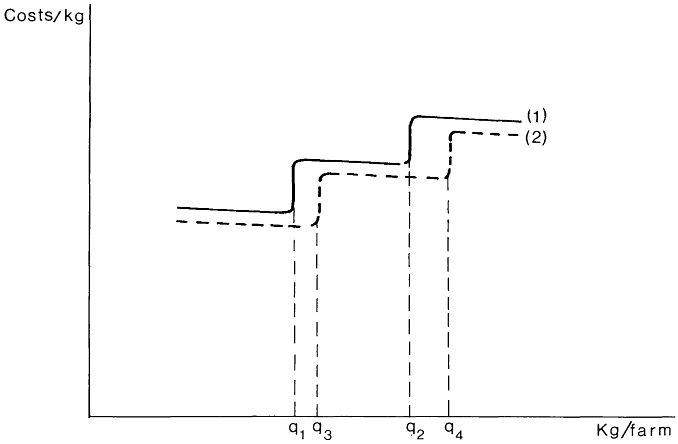

Fig. 3. Marginal production of milk at farm level: (1) without BST; (2) with BST.

without the costs of BST). BST gives a cost reduction (downward shift) while capacity limits (e.g. for domestic roughage or buildings) are reached only at higher production limits. The cost reduction of BST at farm level strongly depends on the particular farm. Under a free market, farms typically operate at the production levels q_1 or q_2 (where marginal costs equal marginal revenue). However, under a quota system production quantities are limited and farmers can operate at very different production levels.

The introduction of BST reduces production costs from the area under cost function (1) to the area under cost function (2) up to the particular production quantity of the farm. As already stated, the costs of BST have been excluded. Clearly, the cost reduction of a farm at production level q_3 is much larger than the cost reduction at production level q_1.

Differences between farms at production levels q_2 and q_4 should be interpreted in a different way. If, above production level q_2, the capacity of buildings were increased, a farm producing q_4 has already invested in new buildings; these 'sunk costs' do not belong to the variable-costs curve. However, if we interpret Fig. 3 in the long term, a farmer who has to renew some of his buildings in future (with quota q_4) could be in a profitable situation by applying BST.

From this methodological discussion one may derive the following conclusions:

(1) Profits from applying BST can differ considerably between farms.

(2) In The Netherlands the following criteria are most useful for ascertaining the profitability of using BST: (a) how much roughage is available on-farm, (b) the alternative uses for land and buildings on farms that could apply BST.

(3) Linear programming seems to be a relevant research technique for analysing the effects of BST at farm level, because production limits and opportunity costs play an important role.

1.2 Methodology at farm level

First a number of typical dairy farm situations will be specified, each representing a group of dairy farms and together as representative as possible of all dairy farms in The Netherlands. Then, for the most important situations, the optimum farm plan will be calculated by linear programming, both with and without BST. The effects of BST at farm level are determined by comparing the two sets of results.

1.3 Methodology at national level

The results of the different optimal farm plans will be aggregated to the national level. When calculating effects at national level, supply and demand for products or production factors are not necessarily in equilibrium. Therefore, several balances at national level will be checked. If any disequilibrium comes to light, new assumptions must be made – mostly about prices in particular farm plans. Because in the farm plans only differences between two optimal situations (with and without BST) will be compared, these differences should be consistent. New prices are introduced until equilibrium results are obtained at national level. These results are used in Section 5 only.

1.4 Data used and general starting points

It will certainly take some years before BST is actually used on normal dairy farms. Moreover, it takes time before innovations become widely accepted.Therefore, there is a difference between the reference year for calculations (1984/85) and the relevant situation at the moment BST can be (or will be) applied. Nevertheless in this study we have used 1984/85 data because:
- they give a complete and consistent description of an actual situation;
- projections of future costs, revenues, prices and quantities would take a considerable time and give large uncertainties;
- the results derived from 1984/85 data give a good picture of the effects to be expected.

With respect to the impact of BST of milk production and feed conversion, several alternatives could be formulated (see Berentsen et al., 1987). In our study we used the following assumptions: a 20% increase in annual milk production, and increased feeding of the dairy cows for the extra milk production according to the usual feeding standards. In addition, it is assumed that the application of BST requires no additional labour and does not affect the health, longevity and other qualities of the animals. Furthermore, it should be mentioned that it has been assumed that there are no opportunity costs of family labour outside the farm. The costs of the BST itself have not been included in the calculations, because it is not yet known what price farmers will be charged for BST. Milk price has been assumed to be unchanged by the application of BST.

2. Dairy farms in The Netherlands

2.1 Specification of the types of dairy farm

The calculations of the farm-level impact of BST in The Netherlands have been based on the representative farm account data of 1984/85 (LEI, 1986). Only farms larger than 79 standard holding units (shu)[5] were represented in the sample surveyed by LEI. As a result, our calculations do not include the smaller farms. In addition, we restricted the calculations to the group of specialized dairy farms. In 1984/85 the group of larger specialized dairy farms included about 57% of all the farms with dairy cows and 69% of those larger than 79 shu. About 75% of the national dairy herd was located on these farms, and they produced 76% of the national milk production.

We classified the specialized dairy farms in the farm survey according to the following criteria:

(1) Whether arable crops are possible. In The Netherlands there are areas with peat soil that are suitable for grassland only. This reduces the alternatives to dairying because arable crops, especially fodder maize, cannot be grown.

(2) The stocking rate of dairy cows per ha. On many farms in The Netherlands, the stocking rate is so high that, in addition to concentrates, a large percentage of the roughage must be bought in. On these farms, the use of BST will mainly cause roughage costs to fall, while the use of the land will hardly change. On the other hand, there are farms with lower stocking rates that produce all the roughage on their own land and only buy in concentrates. On these farms, decreasing the dairy herd will result in a surplus of land for dairying, and the farmers will need to seek alternative uses for their land.

Three stocking rates were considered. Farms with the first stocking rate (<1.9 dairy cows per ha) already have surplus land for dairying. Farms with the third stocking rate (>2.35 dairy cows per ha) always have to buy in roughage. Farms with the second stocking rate (intermediate between the other two) currently have to buy in roughage but will have a surplus of land if they use BST.

[5] The number of shu (in Dutch: sbe) indicates the size of a farm. It is a measure based on value added. For a specialized dairy farm 79 shu corresponds to about 20 dairy cows with additional young stock on 10 ha of grassland.

TABLE 1

Characteristics of the six types of specialized dairy farm in The Netherlands

Variable	Unit	Arable crops possible			Arable crops not possible		
	Cows per ha	<1.9	≥1.9 ≤2.35	>2.35	<1.9	≥1.9 ≤2.35	>2.35
Number of farms	No.	6618	6819	11 396	2654	2885	2795
(% of national milk production)	(%)	11	16.7	28.7	4.6	6.9	8.0
Cultivated area	ha	26.8	28.6	21.6	30.0	27.9	23.9
Labour units	No.	1.5	1.6	1.6	1.5	1.7	1.7
Dairy cows	No.	42.8	59.8	62.4	45.0	58.1	68.0
Calves per dairy cow	No.	0.35	0.34	0.33	0.30	0.29	0.29
Heifers per dairy cow	No.	0.42	0.39	0.38	0.34	0.32	0.32
Nitrogen level grassland	kg N	320	375	390	250	340	400
Milk quota	t	220.5	323.5	335.7	232.6	314.6	381.8
Returns per dairy cow							
Milk:							
- production	kg	5227	5509	5459	5159	5566	5715
- butterfat	%	4.22	4.18	4.16	4.10	4.17	4.18
- price per 100 kg	Dfl.	76.26	75.93	75.93	74.46	75.71	76.11
- gross output	Dfl.	3986	4183	4145	3868	4214	4350
Cattle	Dfl.	792	762	745	688	664	664
Total gross output	Dfl.	4778	4945	4890	4556	4878	5014
Variable costs per cow (excluding feed-costs)	Dfl.	473	469	467	459	456	456
Gross margin per dairy cow (excluding feeding cost)	Dfl.	4305	4476	4423	4097	4422	4558

Farm types classified according to whether arable crops are possible or not, and in terms of three stocking rates. Source: LEI (1986).
t, metric tonne = 1000 kg.

This classification scheme results in six types of specialized dairy farm. The farm situations are defined by the averages of a number of variables per farm, as shown in Table 1. The values in Table 1, supplemented by prices and technical coefficients based on recommended production practices, were incorporated into a farm model to make the calculations. For this we used the computer programme 'Bedrijfseconomisch Advies Rundveehouderij' (Farm Economic Advice for cattle-raising). This programme, based on linear programming, is used in The Netherlands for economic extension work in dairying.

2.2 Alternatives to dairying in the different farm types

As mentioned above, alternatives to dairying differ because of the differences in possible land uses.

TABLE 2

Gross margin per ha for the alternatives to dairying (Dfl.)

Variable	Maize silage	Grass	Beef bulls	Sheep
Gross income	4422	2770	17 595	5532
Variable costs animals	-	-	11 999	1824
Variable costs land	2906	1374	2 906	1203
Gross margin	1516	1396	2 690	2505

If arable crops are possible, a variety of arable crops could be grown. However, most dairy farmers have neither the machinery nor the knowledge and experience needed to successfully produce most alternative arable crops. Fodder maize is the only crop generally grown by dairy farmers. This, plus the high gross margin of fodder maize compared with the gross margins of other suitable arable crops (Van Horne and Sturkenboom, 1985), was why fodder maize was the only alternative arable crop we considered in this analysis. The maize can be sold or used for fattening beef bulls. The number of beef bulls is limited by the existing farm buildings (after adjustments, one cow-place represents 1.5 beef-bull places) and by labour capacity.

If arable crops cannot be grown, the land can only be used for grass production. Fattening beef bulls is not a good alternative here, because fattening on grass silage is not very profitable. The grass can, however, be sold for ensiling, or it can be used for keeping sheep. Table 2 gives gross margins for alternative enterprises.

Finally, it should be noted that starting or extending pig production, poultry or some other intensive livestock production enterprise was assumed to be impossible because of new legislation in The Netherlands (the Manure Act and the Soil Protection Act) which restricts the expansion of such enterprises.

3. Effects of BST at farm level

Given the above assumptions and methodology, the results at farm level are straightforward. Table 3 shows the most important results of the economic optimizations for two farm situations, i.e. for the lowest and the highest stocking rates situations on farms where arable crops are possible. The labour income of the farm was maximized in the optimizations. This is defined as total returns minus total costs, excluding costs for labour and management.

Table 3 shows that, as a result of the boost to milk production per cow from BST, the dairy herd must be decreased; the need for young replacement cattle also decreases. This reduces feed requirements for the farm and idles cowhouse places and labour. On farms with a surplus of roughage, and on those

TABLE 3

Results of the economic optimizations for farms with arable crops possible, at two different stocking rates

Variable	Unit	< 1.9 cows per ha		> 2.35 cows per ha	
		without BST	with BST	without BST	with BST
Permanent grassland	ha	20.1	17.6	21.6	20.7
Maize	ha	6.7	9.2	–	0.9
Milk quota	t	220.5	220.5	335.7	335.7
Dairy cows	No.	42.2	35.2	61.5	51.2
Dairy young stock	No.	32.5	27.1	43.7	36.4
Beef bulls	No.	1.2	11.7	0.8	16.1
Returns					
- cattle	Dfl.	204 649	225 843	303 964	335 346
- maize silage	Dfl.	11 320	18 263	–	–
Feed costs					
- concentrates	Dfl.	29 138	38 071	56 800	65 693
- roughage	Dfl.	–	–	39 008	34 202
Other variable costs					
- cattle	Dfl.	21 173	28 233	29 468	40 011
- land use	Dfl.	45 583	48 968	32 652	33 904
Labour income of the farm	Dfl.	44 128	52 981	62 269	77 818
Labour income per hour	Dfl./h	18	23	20	26

t, metric tonne = 1000 kg.

with a shortage of roughage, the cow-house places that became available are filled by beef bulls. Concerning land use, there is a shift from grassland to growing more maize.

The most important effects of these changes on economic performance are:

- higher returns on cattle and, on the other hand, higher costs of concentrates and other variable costs of cattle.
- higher returns on sales of maize silage at the low stocking rates and lower costs of roughage at the high stocking rates.
- an increase in the variable costs of land-use, because more maize is grown.

Overall, the use of BST increases labour income per farm by Dfl. 8853 at the lowest stocking rate and by Dfl. 15,549 at the highest. This is, respectively, Dfl. 252 and Dfl. 303 per cow (expressed per cow in the situation with BST use). This increase in labour income is realized despite a reduction in labour input. Therefore, labour income per hour increases relatively more.

To obtain more insight into the profitability of BST under different circumstances, calculations were also made under several scenarios. These reflect different assumptions about opportunities for alternative enterprises and about prevailing policy. The results for all farm situations and scenarios are summarized in Table 4. The results discussed above were calculated according to scenario B, in which the alternatives to dairying were selling roughage and either fattening beef bulls or keeping sheep.

Before discussing the other scenarios, mention must be made of the results for farms where arable crops are not possible. Table 4 shows that, in general, the effects on the labour income for these farms are similar to those for the farms on which arable crops are possible. This applies to all the three scenarios.

In scenario A, the only alternative enterprise is selling of roughage. It appears that this change in assumptions has a particularly strong impact on farms with low stocking rates. This indicates that using a surplus of roughage for fattening beef bulls, or keeping sheep instead of selling surplus roughage, increases labour income fairly well.

On the other hand, fattening beef bulls and keeping sheep on purchased feed – which is the case at high stocking rates – is not very favourable.

In scenario C it is assumed that there is no quota system, and that opportunities are the same as under scenario B. Under these circumstances BST would increase labour income from Dfl. 458 to Dfl. 498 per treated cow. In this scenario, the differences between the farm situations are very small and can largely be ascribed to the differences in milk production per cow before BST use. Thus, because it has been assumed that BST boosts milk production by 20%, the increase in the impact on labour income per cow will depend on how high the production level was in the starting situation. Comparing the scenarios shows that the quota system decreases the profitability of BST by about 35% at the high stocking rates and by at least 45% at the low stocking rates.

TABLE 4

Impact of BST on the labour income per cow (expressed per cow in the situation with BST use) under different scenarios (Dfl.)

Variable	Scenarios	Dairy cows per ha		
		<1.9	≥ 1.9 ≤ 2.35	>2.35
Arable crops possible				
only selling maize silage	A	190	239	294
also fattening beef bulls	B	252	277	303
no quota system	C	465	485	477
Arable not possible				
only selling grass	A	163	245	302
also keeping sheep	B	253	268	305
no quota system	C	458	484	498

4. Effects of BST at national level

This section explains how the effects at national level of using BST in The Netherlands were calculated. These calculations were made under the assumption that BST is used only in The Netherlands; a relevant point for determining the repercussions of BST on the EC budget.

The calculations in this section will be based on an equilibrium situation, which will only occur a few years after BST has been generally adopted. Transitional effects caused by the introduction of BST (such as a one-off decrease in dairy cows and followers) have been ignored. Various assumptions were initially made:

(1) Using BST has no influence on the milk price received by dairy farmers.
(2) No costs of BST have been included in the calculations (because the price of BST is unknown).
(3) The reactions of those farms for which no calculations at farm level have been made can be derived from calculations for similar model farms.
(4) The adoption rate of BST is 30% on specialized farms and 20% on mixed farms. (These percentages refer to cow numbers.) This results in an average adoption rate of 27.8%, which implies that BST will be used on 27.8% of cows.
(5) Beef and veal are easy substitutes in consumption.
(6) A number of assumptions are made relating to the side-effects of BST (see Berentsen et al., 1987, chapter 4).

Later in this paper the first, second and fourth assumptions will be further elaborated (see Subsection 5.2).

4.1 Consistency at a national level

In calculating the effects of BST at farm level, a number of quantity changes could be derived. Such changes, however, could be inconsistent at national level if supply and demand for products or production factors are not in equilibrium. Therefore, several balances at national level were checked (see Subsection 1.3).

Table 5 presents the aggregate results from the original farm plans (see Section 3); the equilibrium situation is shown on the right-hand side. The recalculation to arrive at an equilibrium situation mostly affects:

(1) The number of veal calves. The reduction in the number of calves due to the decrease of cows and the increase in the number of beef bulls is entirely at the expense of calves destined for the veal sector.
(2) The area of silage maize. Because there is a surplus of silage maize, the gross margin for silage maize is considerably lower than in the original farm plans. Therefore the production of grain (winter wheat with a gross margin of Dfl. 1000 per ha) has been introduced as an alternative.

TABLE 5

Size and number of variables after aggregating the results at farm level

Variable		Situation without BST (×1000)	Percentage change (simple aggregation)	Equilibrium situation: change (×1000)	percentage change	situation with BST (×1000)
Dairy cows	(no)	2 367	−4.7	−111	−4.7	2 256
Male calves	(no)	1 184	−4.7	−56	−4.7	1 128
Sold female calves	(no)	395	−4.7	−19	−4.7	376
Culled dairy cows and followers	(no)	821	−4.7	−39	−4.7	783
Beef bulls	(no)	218	+63.3	+138	+63.3	356
Veal calves	(no)	1 100	-	−212	−19.3	888
Sheep	(no)	814	+8.5	+36	+4.4	850
Concentrates	(t)	16 000	+0.9	+69	+0.4	16 069
Permanent grassland	(ha)	1 127	−1.6	−13	−1.2	1 113
Maize	(ha)	177	+10.5	+5	+2.8	182
Grain	(ha)	184	-	+8	+4.6	192

(3) A somewhat lower reduction of permanent grassland.

(4) The increase in the number of sheep causes market prices for sheep to fall. A price elasticity of demand for sheep from The Netherlands equal to −0.5 has been used.

The results from the last column of Table 5 were used for further analyses.

4.2 Effects on producers, consumers, budget and national income

The change in national income can be derived by identifying the effects for producers, consumers and government budget (Just et al., 1982). Application of BST, however, influences other agricultural producers as well as dairy farmers (see Table 6). Furthermore, important changes in the agricultural sector can affect income generation in related stages of the production column. (For details and specific assumptions see Berentsen et al., 1987, pp. 41–42.) Due to the assumptions made at the beginning of this section, effects on consumers and the contribution of The Netherlands to the EC budget are limited (see Table 6).

Total annual increase of national income is about Dfl. 120 million. However, any costs of BST should be deducted and an unchanged milk price has been assumed.

TABLE 6

Annual effects of a 27.8% adoption rate of BST for producers, consumers and government budget for The Netherlands (Dfl. million)

Producers' income		
- increased income dairy farmers		172.6
- decreased income silage-maize producers (not dairy farmers)	14.8	
- decreased income sheep farmers (not dairy farmers)	21.0	
- decreased income veal calf farmers	15.3	
- decreased income milk powder producers	4.1	
		−55.2
		117.4
Consumers' income		
- increased consumers' income due to lower mutton price		+6.0
		123.4
Government budget		
- Extra contribution to EC budget for sale of skimmed milk powder	4.0	
- extra contribution to EC budget for grain subsidies	0.6	
		−4.6
Total increase in national income		118.8

5. Discussion

The results of the calculations presented in the preceding sections were based on several assumptions. In this section we will especially discuss the sensitivity of the results with respect to a number of important assumptions.

5.1 Farm level

Cost of BST

In the linear programming calculations no costs of BST were incorporated. To determine the profitability of BST for the farmers, therefore, the net returns in the tables should be decreased by the costs of BST.

BST effect

Recent results of experiments with BST in The Netherlands (Rijpkema et al., 1987; Oldenbroek et al., 1989) indicate that the effect of BST on milk production is independent of the cows' yearly milk production without BST. However, for our calculations we assumed that the effect of BST would be proportional to 20% of the yearly milk production. So in our calculations the profitability of BST rises according to how high milk production was in the starting situation. At a BST effect of 20% and a high stocking rate, 100 kg more milk in the starting situation results in about Dfl. 5.00 more profitability under the quota system and about Dfl. 9.00 without the quota system.

The experiments mentioned above indicate that the effect of BST on milk production is less than 20%. Additional calculations showed that a smaller production effect results in a nearly proportional decrease in the profitability of BST.

Prices of feed, beef bulls and sheep

In the present situation, where milk production is controlled by quota per individual farm, the profitability of BST largely depends on the decrease in feed costs and on the profitability of the alternatives to dairying. So the assumptions concerning the prices of feed, beef and sheep are especially important. Since 1985 feed prices have decreased considerably and prices of beef and sheep have also fallen. In the present situation the profitability of BST, therefore, will be lower than calculated here. To give some indication:

- a 20% decrease in feed prices in scenario A results in Dfl. 65–75 per cow less profit from BST;
- a 20% decrease in feed prices together with a 10% decrease in beef and sheep prices in scenario B also results in Dfl. 65–75 less profit per cow.

Application of BST

In the calculations, BST has been considered as a production factor used on all dairy cows in the herd according to one general strategy. However, like the feeding of cows, the strategy for applying BST will probably be to consider individual cows, i.e. to take account of the response of the individual cows. The better the response of a cow, the more profitable the application of BST to that cow.

As well, BST could be used for special management purposes, e.g.:

- to manage the total milk production to fill up the milk quota at the end of the year;
- to affect the percentage of winter milk.

These special applications of BST will probably be very profitable.

Concluding remark

From the above analysis it can be concluded that the application of BST will be more profitable on intensive farms and on farms with more opportunities for land, buildings and labour. On intensive farms, apart from decreasing the herd size, there is no need to make further adjustments to the farm. On extensive farms an alternative profitable enterprise has to be started to make BST profitable.

5.2 National level

Adoption rate and BST effect

We assumed an adoption rate of 27.8% and a milk production increase of 20% for cows where BST has been used. Of course, in practice the costs of BST and the expected milk production effect will influence the adoption rate. We did not investigate this relation. The effect on national income of a lower adoption rate and a smaller production effect is nearly proportional to the effect of a higher adoption rate and a larger production effect. However, there are some non-linearities (although they are not major):

- Additional production of mutton and lamb leads to a non-linear reduction in the revenue from sheep farming. This is because of a price elasticity of demand for mutton and lamb of -0.5 and a relatively large proportion of exports.
- A higher adoption rate or a larger increase of milk production per cow will influence gross margins of silage maize, resulting in a more than proportional loss for silage maize producers. However, with a too low gross margin for silage maize, grain production will increase by a fixed gross margin per hectare for producers and so will the fixed budget effects per additional hectare. Thus, above some limit, the effects are again proportional.

For practical purposes, however, a proportional relation can be used.

Change of milk price

An unchanged milk price is an important assumption in this analysis. A lower milk price would have important effects on the national income of The Netherlands, because 60% of milk production will be exported. Therefore, producer losses are much larger than consumer gains. A drop of 1% (0.0075 Dfl. per kg) in the milk price means that producers' income decreases by Dfl. 90 million while real consumer income rises by Dfl. 36 million. This implies that national income decreases by Dfl. 54 million.[6] This illustrates the importance of the assumption about milk prices.

Cost of BST

Because no costs of BST have been included, the calculated effects for dairy producers and also for the national income of The Netherlands are overestimates. If we assume that all BST will be imported and trade margins can be ignored, a price of Dfl. 190 per cow lactation will completely offset the calculated increase of national income. In such a situation dairy farmers applying BST would make more profit. However, other producers, especially of silage maize, veal and sheep will still suffer an income reduction, so that the total income effects of producers can be even negative. This is a classic picture of technological change (Cochrane, 1958).

Application of BST in other countries

If BST were applied in other countries inside and outside the EC, the results of our analysis would be completely different. Recent overviews of cost reduc-

[6] Here the effect of a lower milk price on export refunds and intervention subsidies of the EC has been ignored. It is unlikely that BST will be used only in The Netherlands. An international price drop equal to the cost reduction can be expected.

tions applying BST indicate that profitability varies among different countries, albeit to a limited extent (Thiede, 1987). As may be expected, a cost-decreasing technique would be followed by a price decrease of milk and also by price-depressing effects for related products like beef and sheep (Frohberg, 1987) and maybe also feed inputs. If The Netherlands were the only exception, by not applying BST the effects of the price decrease for producers and the additional budget costs of the EC (and therefore of The Netherlands) would outweigh the increase of consumer income in The Netherlands. Here the mechanism can be compared with the situation at farm level. The application of BST by some of the farms (countries) will depress the income situation of other farms (countries), especially if average cost reductions are followed by price falls. Therefore, the introduction of BST by some countries will have a large influence on the decision by others.

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