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Economic and environmental consequences of technical and institutional change in Dutch dairy farming

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Abstract

A linear programming model of a dairy farm is used to explore the future for different types of Dutch dairy farms under different scenarios. The scenarios are consistent sets of changing factors that are considered external at farm level. The factors are either technical, like efficiency of milk production and feed production, or institutional, like national environmental legislation and EU market and price policy. Income and nutrient losses for farms differing in intensity and size are generated for the base year 1992 and for 2005. The results show that technical change up to 2005 has a positive influence on labour income as well as on nutrient losses. The increase of labour income is higher for farms with a higher total milk production in the basis situation. The influence of environmental policy on labour income and environmental results is bigger for farms with a higher intensity, as these farms have to take more measures to comply with governmental policy. Replacement of the price support policy for milk by a two-price system with a high price for a restricted amount of milk and a low price for an unrestricted amount of milk has negative consequences for labour income, especially for intensive farms.

Keywords: forecasting, modelling, dairy farming, scenarios, technical change, institutional change

Introduction

Future possibilities for dairy farming depend strongly on technical and institutional change which can be considered external at farm level. On a dairy farm the state of technology is expressed by the efficiency of fodder production and animal production. Institutions strongly influence prices of inputs and outputs in dairy farming (European Union) and environmental restrictions that dairy farmers have to fulfil (national government).

Several studies have been conducted to forecast the future of Dutch agriculture in general and dairy farming in particular. Studies of Muller *et al.* (1993) De Groot *et al.* (1994) and Kolkman *et al.* (1993) include technical and institutional change in the scenarios applied. However, verification of these scenarios and the consequential results is difficult as the development of the scenarios is rather vague and the results are described in global non quantitative way. Other studies focus on the effects of only one changing factor. An example of this are studies that try to asses the effects of a future environmental policy (Van de Ven, 1996; Berentsen *et al.*, 1992).

The objective of this paper is to determine economic and environmental consequences of a number of scenarios including technical and institutional change up to 2005 for different dairy farms on sandy soil in the Netherlands. The dairy farms differ with respect to intensity and size, which are two aspects with a substantial impact on farm results. Sandy soil is chosen because in the Netherlands this soil type has the severest environmental problems.

A linear programming model of a specialized dairy farm has been developed to simulate the different situations (Berentsen & Giesen, 1995). This model was validated based on the average results of a representative sample of dairy farms on sandy soil in the Netherlands in 1992 (Berentsen *et al.*, 1996b). The consequences of the scenarios are determined by comparing the results for 2005 with those of 1992.

Scenarios of technical and institutional change

The overview of the scenarios (Figure 1) shows that there is one forecast for technical change; one for farm size; there are two forecasts for national environmental policy and two for the market and price policy of the EU. This results in four scenarios (see also Berentsen *et al.*, 1996a).

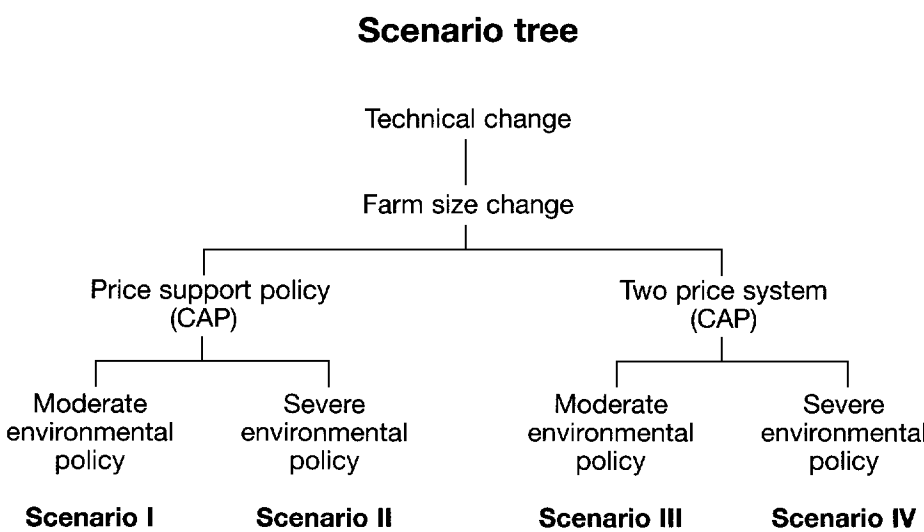

Figure 1. Scenarios of technical and institutional change in Dutch dairy farming.

Technical change in fodder production and milk production are the result of breeding activities and of management improvement. For fodder production in general, improvement of management includes drainage of wet soils, water supply to dry soils, improvement of soil fertility and soil structure and improvement of crop care. For grass production in particular, improved management includes also better timing of grazing and harvesting and better methods of harvesting and ensiling grass. Improvement of management in milk production is characterized by better feeding management and health care and, since the introduction of the milk quota system, by increased selection of cattle. Table 1 shows the production levels of specialized Dutch dairy farms on sandy soil in 1992 and a forecast for the production levels in 2005 based on the levels of 1992 and on analysis of historic production data (Berentsen *et al.*, 1996a).

Environmental problems related to dairy farming are acidification and eutrophication. Calculations show that Dutch agriculture was responsible for 32% of total acid deposition in the Netherlands in 1990, almost entirely through volatilization of NH_3 from manure in sheds, in storage and on the land (Anonymous, 1993, p. 80). Eutrophication of ground water by P_2O_5 and NO_3 is mainly caused by excessive use of animal manure and fertilizer by agriculture. It threatens the use of ground water as drinking water. National environmental legislation so far focussed on methods of storing and applying manure to decrease NH_3 volatilization, and on the period during which manure can be applied and on the amount of manure that can be applied per hectare to decrease P_2O_5 and NO_3 leaching. For the future the government is going to introduce a system of nutrient balances for N and P_2O_5 at farm level with a levy that will be imposed on losses that exceed an acceptable level. For NH_3 emission the government is studying a system that estimates NH_3 emission at farm level and imposes a levy on emission exceeding an acceptable level. Here it is assumed that in 2005 a

Table 1. Expected technical change for specialized Dutch dairy farms on sandy soil.

	Year	
	1992	2005
Grass production:		
– yearly gross energy production (1000 MJ NEL/ha) at:		
* 100 kg N/ha	46.3	56.0
* 200 kg N/ha	59.8	71.9
* 300 kg N/ha	68.1	81.9
* 400 kg N/ha	72.9	87.7
* 500 kg N/ha	75.2	90.2
– loss of energy by grazing (%)	22.0	18.8
– loss of energy by mowing and ensiling (%)	20.0	16.8
Gross energy production silage maize (1000 MJ NEL/ha)	82.8	92.9
Gross energy production fodder beet (1000 MJ NEL/ha)	100.7	109.7
Milk production per cow (kg/year)	6682	8445

system with acceptable emissions and levies will be used for both NH_3 emission and N and P_2O_5 losses (Table 2). Because of uncertainty about the NH_3 system and about the exact path through time of the nutrient balances system two alternative policies are assumed.

For the influence of the EU market and price policy on dairy farming the years 1992 and 2000 are important. In 1992 the EU members reached an agreement, which extends to 2000, on a derivate of the MacSharry proposals with a number of consequences for dairy farming. The decrease in the intervention price of grain by 30% will lead to a decrease in the price of concentrates, as the prices of grain substitutes are linked to the prices of grain. The compensatory payment per hectare of grain (which applies also to silage maize) decreases the price of purchased silage maize and the costs of own produced silage maize. As a result of a decrease in the intervention price of beef by 15%, prices of removed cattle and young stock will decrease. The intervention price for milk will decrease by NLG 0.50 per 100 kg, as a result of a decrease in the intervention price of butter by 5% on the one hand and the abolition of the co-responsibility levy of NLG 1.50 per 100 kg milk on the other hand. Moreover, the milk quota will be reduced by 2%. Table 3 shows the consequential prices for 1992 and 2005. In 2000, EU member states will have to reach agreement on policy after 2000. As milk is one of the products left with a substantial price support, it is possible that this price support and the quota system will be changed. For the situation in 2005 two alternatives are assessed. The price support alternative is a continuation of the situation before 2000. The second alternative is a two-price system with a guaranteed high price (the same price as in the price support alternative) for 85% of the available milk quota and a super levy on the unrestricted production of about 50% of the guaranteed price (so that a price of NLG 40 per 100 kg remains).

Table 2. Two variants of expected environmental policy for 2005 concerning nutrient losses from dairy farming.

	Policy	
	Moderate	Severe
Ammonia emission:		
– acceptable emission level (kg NH_3/ha)	40	25
– levy (NLG/kg NH_3)	30	60
Phosphate losses[1]:		
– acceptable losses (kg P_2O_5/ha)	35	20
– levy on first 10 kg exceeding (NLG/kg P_2O_5)	5	5
– levy on higher exceeding (NLG/kg P_2O_5)	20	20
Nitrogen losses[1]:		
– acceptable losses (kg N/ha)[2]	275	180
– levy (NLG/kg N)	2	2

[1] Source: Anonymous (1995a)
[2] N losses through atmospheric deposition are not included

Table 3. Prices (in NLG[1]) of inputs and outputs in 1992 and 2005.

	Year	
	1992	2005
Inputs:		
– standard concentrate (NLG/100 kg)	34.60	30.60
– purchased silage maize (NLG/ha)	3300	2696
Outputs:		
– male calf (NLG/animal)	370	270
– replaced dairy cow (NLG/animal)	1363	1163
– milk (NLG/100 kg)	79.00	78.50
Premium silage maize (NLG/ha)	–	604

[1] NLG 1 equals about 0.6 US$

Due to exit of some dairy farms the average size of dairy farms measured in available land and milk quota is continuously growing. Based on historical data it is assumed that the average size yearly increases by 4000 kg milk quota and by 0.4 ha per year.

Methodology

The farm model

A linear programming model is used to model the dairy farm. The objective function maximizes labour income (i.e. return to labour and management) as maximization of income appears to be the most general first objective of farmers (Zachariasse, 1974). The basic element in the model is a dairy cow, calving in February and producing a fixed amount of milk. Feed requirements are determined using formulas of Groen (1988). For protein feeding, a safety margin of 300 gram per cow per day (200 gram OEB and 100 gram DVE) is included in the requirements to reflect uncertainty about exact feed intake in reality (Berentsen *et al.*, 1996b). In order to be able to replace cows, young stock is kept on the farm. An eventual surplus of pregnant heifers can be sold.

The land of the farm can be used for growing grass, maize, and fodder beet. Grass can be grown at different levels of N supply and it can be used for grazing and for silage making. Maize can be grown for silage making, and can be fed in winter and summer. Fodder beet can be grown for feeding in winter. In addition to home-grown feed, different types of concentrate (with different protein content), dried beet pulp and silage maize can be purchased. All feed supplies energy, protein and dry matter and uses part of the intake capacity of the animals.

Nutrients for plant production can be supplied by home-produced manure, by fertilizer, and (to a certain extent) by manure supplied by other farms. The model contains nutrient balances at the farm level for N, P_2O_5 and K_2O that register nutrient input and output and consequently nutrient losses. NH_3 emission is estimated separately and is affected by housing, type of manure storage and application, and by extent of grazing. To make realization of the ammonia emission targets possible, adaptation of the stable is included in the model. Emission reduction percentages and costs are based on Van der Kamp *et al.* (1993). Calculation of N leaching is based on calculation rules of Goossensen & Van Den Ham (1992). Given soil type and ground water table, leaching depends on the use of the land (i.e. grass, maize of fodder beet production), on the N level on grassland and on the intensity of grazing (number of urine patches).

In the model, labour is supplied by the farmer and the family. Activities such as mowing and ensiling of grass and application of manure can be done with the farmer's own machinery or can be contracted out. Investment in land, housing capacity and basic machinery are not optional, therefore these costs are calculated separately from the LP model. For a more detailed description of the model see Berentsen & Giesen (1995).

Organization of the analysis

The average area of specialized dairy farms on sandy soil in 1992 was about 27 ha and the average quota was about 330.000 kg. The capacity of the stable is calculated from the numbers of animals on the farm and it appears to be capacity for 55 dairy cows plus young stock (Berentsen *et al.*, 1996b). On the average farm, 166 m^3 of pig manure is used besides manure produced by the own cattle. Growth of area and milk quota according to the scenarios suggests an area of 32.2 ha in 2005 and a milk quota of about 374,000 kg. The first step of the analysis concerns optimization of this farm for the situations of 1992 and those of 2005 according to the four scenarios. This step includes a detailed comparison of the technical, economic and environmental results.

Next, intensity (by a change of milk quota) and scale (by a change of milk quota and of area) are varied to asses the effects of intensity and scale on economic and environmental results. Intensity and scale are varied separately in order to examine their distinct impact on results. Figure 2 gives an overview of the area, quota and intensity for 1992 and 2005 of the basis farm (indicated as farm A) and all alternative situations. The horizontal dimension in this figure is the scale, expressed in hectares and milk quota. The vertical dimension is the intensity, expressed in quota/ha. To ease interpretation of the results, differences in intensity and scale are chosen such that farm B and D on the one hand and farm C and E on the other hand have the same total quota. Comparison of farm B with D and of farm C with E shows the effects of intensity because of different areas. The quota for 2005 used in Figure 2 represents the price support policy (scenario I and II). For the two-price system (scenario III and IV) the quota is 15% lower. The intensity of farming for these scenarios results from the calculations.

Sensitivity analysis is carried out for the average farm, with special attention to

B	1992	2005
Area	27	32.2
Quota	220	267
Quota/ha	8.15	8.28

D	1992	2005
Area	18	22.9
Quota	220	267
Quota/ha	12.22	11.63

A	1992	2005
Area	27	32.2
Quota	330	374
Quota/ha	12.22	11.63

E	1992	2005
Area	36	41.5
Quota	440	482
Quota/ha	12.22	11.63

C	1992	2005
Area	27	32.2
Quota	440	482
Quota/ha	16.3	14.97

Figure 2. Area (ha), quota (×1000 kg) and intensity (1000 kg/ha) for 1992 and 2005 of the average specialized dairy farm(A) and four alternative farming situations.

the increase of grass production. In Berentsen *et al.* (1996a), it is noted that the increase of grass production, especially at low levels of N supply, is hard to forecast. The general shape of the grass production curve shows a decreasing marginal production at increasing N supply which means that grass production per kg N supply is higher at low levels of N supply. A consequence could be that the possibilities to increase grass production at low N supply are relatively smaller than at high N supply. To examine the consequences of such an assumption, calculations are made with energy production from grass at an N supply of 500, 400, 300, 200 and 100 kg/ha that is based on a yearly increase that amounts to 100, 85, 70, 55 and 40% of the initial increase respectively.

Results

The average farm

Table 4, 5 and 6 show the technical, the economic and the environmental results. The optimized situation for 1992 is the basis on which the situations resulting from the scenarios are compared.

In the basis situation, the available milk quota and the milk production per cow result in 49.4 dairy cows (Table 4). The number of young stock is restricted by the available grass. As the total area is used for grassland, producing additional grass to raise more young stock can only be realized by using a higher N level. This appears to be economically unattractive. To meet the feeding requirements, silage maize and concentrates are purchased. The farm plan results in a labour income of NLG 70,834 (Table 5). Table 6 shows the balances of N and P_2O_5 at the farm level. Input of nutrients takes place by purchase of concentrates, roughage and fertilizer, by the use of

Table 4. Technical results of the average specialized dairy farm on sandy soil for 1992 and for 2005 using four scenarios.

	1992	2005			
		Price support policy		Two price system	
	Basis	Mod. env. policy	Sev. env. policy	Mod. env. policy	Sev. env. policy
Milk quota (1000 kg)	330	374	374	318	318
Milk production above quota (1000 kg)	–	–	–	150	66
Cattle:					
– dairy cows	49.4	44.3	44.3	55.4	45.5
– young stock	46.9	45.8	35.4	44.3	36.3
Land use:					
– total area (ha)	27	32.2	32.2	32.2	32.2
– grassland (ha)	27	23.9	24.8	28.1	25.7
– N level grassland (kg/ha)	320	200	157	200	153
– silage maize for on farm use (ha)	–	6.9	6.4	4.1	6.5
– silage maize for sale (ha)	–	1.4	1.1	–	–
Feed purchased:					
– silage maize (ha)	8.0	–	–	3.9	–
– concentrates (1000 kg)	70.1	92.3	92.1	114.6	94.7

animal manure from farms with pigs (which is common practice on sandy soil in the Netherlands). Output takes place through milk and meat. Harmful N losses consist of NH_3 emission and of N leaching. NH_3 emission is expressed in kg NH_3/ha to make the value comparable with the standards for 2005.

In 2005, the total area and the milk production per cow have increased. Under scenario I and II, the milk quota has also increased. From Table 6 it appears that all nutrient losses under scenario I are lower than the acceptable losses, meaning that the moderate environmental policy has no impact on the farm plan under scenario I. The increase in milk production per cow and the increased milk quota results in 44.3 dairy cows (Table 4). The number of young stock is maximal given the number of female calves that are born per year. The lower number of cattle and the higher production per hectare of grassland results in a lower area of grassland (23.9 ha) and a lower N level on grassland (200 kg/ha). The rest of the area is used for growing silage maize, part of which is sold. Since higher producing cows need more concentrates, purchase of concentrates increases. Total revenues increase because of higher milk production, silage maize sales, and the EU compensatory payment for silage maize (Table 5). The feed costs are lower because of lower prices and because no silage maize is purchased. The other variable costs are higher as a result of the larger total area and the larger area of silage maize. The costs of contract work of a hectare of silage maize are much higher than of a hectare of grassland which is mainly grazed. Costs of land and buildings increase because of the larger area and because

Table 5. Economic results (NLG) of the average specialized dairy farm on sandy soil for 1992 and for 2005 using four scenarios.

	1992	2005			
		Price support policy		Two price system	
	Basis	Mod. env. policy	Sev. env. policy	Mod. env. policy	Sev. env. policy
Revenues:					
– milk	260,812	293,682	293,682	309,852	276,139
– cattle sold	41,610	34,118	25,691	32,150	26,373
– silage maize sold		2320	1856		
– EU compensation silage maize		5024	4510	2484	3947
total	302,422	335,144	325,740	344,485	306,458
Costs:					
– feed purchased	55,232	32,117	31,269	51,104	32,137
– fertilizer	6206	3322	2195	2566	1890
– other variable costs	46,304	61,106	56,783	60,036	56,877
– land and buildings	55,269	63,203	74,041	63,203	74,041
– quota purchased	19,770	37,970	37,970	37,970	37,970
– other fixed costs	48,807	48,807	48,807	48,807	48,807
– levy			248	1163	1282
total	231,588	246,525	251,313	264,849	253,004
Labour income	70,834	88,619	74,427	79,636	53,454

of the obligation to close the manure storage. The growth of the milk quota is realized by purchase of quota, which increases the cost. Changes in revenues and costs result in a labour income that is some 25% higher than in 1992. The input of N per hectare has decreased considerably because of the absence of roughage purchased and a lower overall fertilization level (Table 6). N output increases particularly because of silage maize that is sold. The net result is a tremendous decrease in N losses of 184 kg/ha. The lower number of cattle, coverage of manure storage and the larger area lead to a decrease in NH_3 emission of 29 kg NH_3/ha. N leaching is decreased by 20 kg/ha due to lower N use on grassland. P_2O_5 input is decreased mainly because no roughage is purchased. The lower P_2O_5 output through culled cows is compensated by higher output through silage maize sold.

A comparison of the acceptable losses with the realized losses in Table 6 shows that the farm plan under scenario II is governed by the acceptable NH_3 emission. Total N losses are much lower than the acceptable losses, while P_2O_5 losses are slightly higher than the acceptable losses. Table 4 shows that the number of young stock is minimal given the replacement rate. The N level on grassland is decreased to a level that makes it possible to meet the acceptable NH_3 emission while still producing enough grass. To reduce NH_3 emission, part of the concentrates consists of dried beet pulp, which has a low protein content. Compared to scenario I, the revenues are lower because of the lower number of young stock and because less silage maize is

Table 6. Environmental results of the average specialized dairy farm on sandy soil for 1992 and for 2005 using four scenarios. Between brackets the acceptable losses.

	1992	2005			
		Price support policy		Two price system	
	Basis	Mod. env. policy	Sev. env. policy	Mod. env. policy	Sev. env. policy
Nitrogen[1] (kg N/ha):					
– input	436	255	223	286	220
– output	80	83	79	90	74
– losses	356	172 (328)	144 (233)	196 (328)	146 (233)
– of which NH_3 emission (kg NH_3/ha)	65	36 (40)	25 (25)	41 (40)	26 (25)
– of which N leaching (kg N/ha)	55	35	28	33	26
Phosphate (kg P_2O_5/ha):					
– input	72	63	54	61	52
– output	35	35	33	38	31
– losses	36	29 (35)	21 (20)	23 (35)	21 (20)

[1] Included in this table is N input through deposition which amounts 53 kg/ha for N. Consequently, acceptable N losses are 53 kg/ha higher than in Table 2.

sold (Table 5). The lower N level on grassland leads to lower fertilizer costs. The other variable costs are lower than under scenario I because of the lower number of young stock and the smaller area of silage maize. The levy on NH_3 emission requires investment in adaptation of the stable to decrease emission. This raises the costs of land and buildings. Summarizing, labour income returns to a level only slightly higher than in the basis situation, which means that replacement of the moderate by the severe environmental policy costs the farm about NLG 14,000. Compared to scenario I, the input of N has decreased because of lower fertilizer input (Table 6). N output has decreased, mainly as a result of selling less silage maize. Consequently, total N losses are 28 kg/ha lower than under scenario I. This decrease to far below the acceptable level is caused by the NH_3 emission policy. A low N level on grassland, for example, results in a relatively low N content of grass, a low N content of manure and as a result in lower NH_3 emission and lower N leaching. P_2O_5 input decreases mainly because of the use of dried beet pulp, which has a low P_2O_5 content. The output of P_2O_5 decreases because of the smaller amount of silage maize that is sold.

Under scenario III, the milk quota is decreased by 15%, but milk production at a price of NLG 40 per 100 kg is not restricted. Total production is limited by the available stable places. Building extra places is not an option in the model. The shadow price of stall places, which amounts NLG 340, indicates that building extra places would not be economically attractive. Under scenario III, milk production at the low price is beneficially. All the available places are filled with dairy cows while the number of young stock is minimized (Table 4). In this situation, total milk production is raised to 468,000 kg, some 25% higher than under scenario I and II. The moderate environmental policy allows grass production at an N level of 200 kg/ha. The higher number of animals requires extra purchase of silage maize and concentrates. In spite of the 25% increase in milk production, total revenues are only 3% higher than under scenario I (Table 5). This is caused by the lower quota with the guaranteed price and by the lower price for unrestricted production. The higher number of animals than under scenario I leads to higher costs of feed purchased. Comparing labour income under scenario III and I, it appears that at the moderate environmental policy, the replacement of the price policy system by the two-price system leads to a decrease in income of about NLG 9,000. The higher intensity of the farm leads to a higher N input than under scenario I, mainly through more purchased feed (Table 6). N output is higher than under scenario I because more milk is produced and more cows are culled. N losses are higher than under scenario I, but still far below the acceptable losses. Since NH_3 emission is strongly related to the numbers of animals, it is higher than under scenario I and notably above the acceptable level of 40 kg/ha, so levy has to be paid. N leaching is lower than under scenario I due to the lower area of silage maize. Compared to grassland fertilized at a moderate N level, silage maize causes more N leaching. This is the result of the absence of a crop on maize land in the winter period when organic N that mineralizes is subject to leaching. P_2O_5 input is lower than under scenario I because the area of grassland is higher and grass fertilized at a low level requires less P_2O_5 than silage maize. The output is in line with the production of milk and meat. Consequently the losses are lower than under scenario I and far below the acceptable level.

Scenario IV combines the two-price system with the severe environmental policy. Given a minimal number of young stock and an investment in stable adaptation to decrease NH_3 emission, the number of dairy cows and the N level on grassland are adjusted such that protein requirements for the stable period (both OEB and DVE) are exactly fulfilled, while NH_3 emission above the acceptable level is minimized. The result is a total milk production that is only slightly higher than under scenario I and II (Table 4). To satisfy the feeding requirements, only concentrates have to be purchased. The low price for part of the milk production results in total revenues that are about 6% lower than under scenario II (Table 5), the scenario which is comparable as far as environmental policy is concerned. At the severe environmental policy, the two-price system results in a reduction in labour income by some NLG 20,000 compared to scenario II. Input, output and losses of nutrients are practically identical with those under scenario II (Table 6).

In summary, comparison of the results of scenario I with the basis situation shows that assumed technical change contributes substantially to a higher income and to lower environmental losses. Hence, the moderate environmental policy has no influence on the results. Introduction of the severe environmental policy almost completely offsets the income increase caused by technical change. The combination of moderate environmental policy and the two-price system leads to a considerable increase in total milk production, but only to a moderate increase in income because of the lower milk price. Scenario IV, the combination of the severe environmental policy and the two-price system, is a worst case scenario as far as labour income is concerned.

Differences in intensity because of different milk quota (farm B and C)

In the basis situation the extensive farm (B) has a lower number of dairy cattle (which follows from the lower quota), a lower N level on grassland, a smaller area used for grassland, it sells roughage in stead of purchasing, and it purchases a lower amount of concentrates compared to the average farm (A). Consequently, labour income is lower. The opposite holds for the intensive farm (Figure 3).

Going from the basis situation to the situation under scenario I, all farms react in nearly the same way. Numbers of dairy cattle are decreased and the N level on grassland is decreased. The area of grassland is decreased, except for the intensive farm that has a shortage of grassland in the basis situation. Comparison of the labour income under scenario I with that in the basis situation indicates that the increase of labour income is strongly related to the labour income in the basis situation (Figure 3). Obviously, production possibilities for the future follow from present production. The environmental results show that only the intensive farm has a NH_3 emission that is slightly higher than acceptable. The resulting levy levels out the income differences to some extent. The P_2O_5 losses of the intensive farm are lower then of the other farms because of the partial replacement of concentrates with a high P_2O_5 content by dried beet pulp with a lower P_2O_5 content. Dried beet pulp, which has also low protein content, is used to decrease NH_3 emission.

When the severe environmental policy is introduced (scenario II), the differences in intensity lead to sharply different results. The extensive farm can meet the accept-

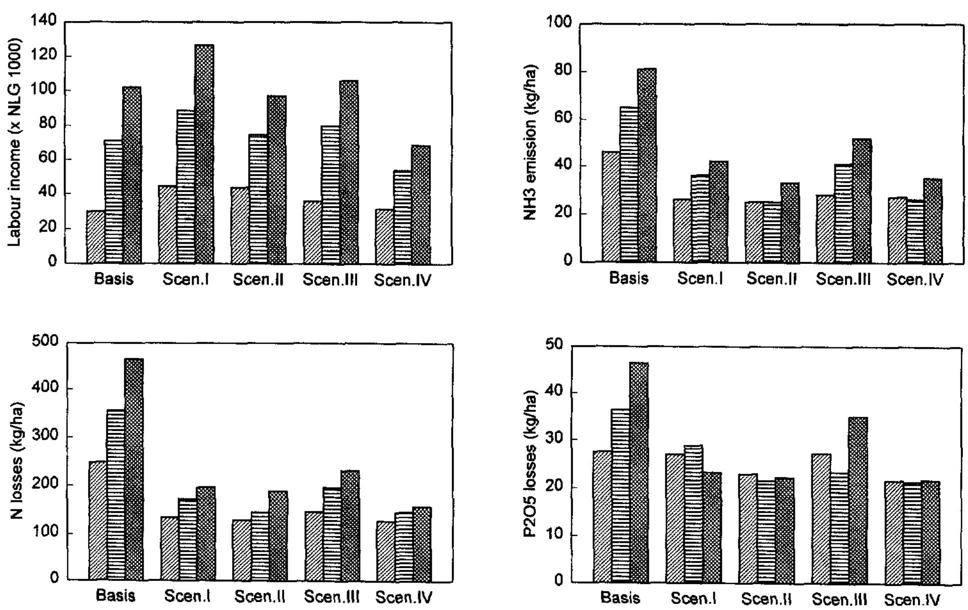

Figure 3. Labour income and nutrient losses for the extensive (▨), the average (☰) and the intensive (▩) farm in the basis situation and under four scenarios.

able losses with only some decrease in the N level on grassland and small changes in the feed ration. Consequently, income remains almost the same as under scenario I. The average and the intensive farm also have to invest in adaptation of the stable to decrease NH_3 emission. For the intensive farm, unacceptable NH_3 emission remains and a substantial levy has to be paid. The result is a fall of the income to a level lower than that in the basis situation.

Under scenario III, which combines the two-price policy with moderate environmental policy, all farms produce the maximum amount of milk given the available cow places in the stable. This results in a total milk production of 312,000 kg for the extensive farm and 614,000 kg for the intensive farm. The result is a labour income of about the same level as in the basis situation. For the average and the intensive farm, the levy for exceeding the acceptable NH_3 emission, which is a consequence of the high number of animals, levels out the income differences to some extent. The levy paid is not high enough to require adaptation of the stable.

The combination of the severe environmental policy and the two-price policy results in a total milk production on the intensive farm of 409,000 kg, which is the amount that has a guaranteed price. The extensive farm is less hindered by environmental legislation and produces the same total milk production as under scenario III. The extensive farm has to make some changes in the farm plan and in the rations to meet the acceptable level of P_2O_5 losses. This results in a small decrease in income compared to scenario III. For the intensive farm, the decrease of returns and the substantial levy on NH_3 emission decreases income to almost half of the income under the favourable scenario I.

Differences in scale (farm D and E)

Farm D and E in Figure 2 have the same intensity as farm A, but they differ in scale. Having the same intensity means that not only the market and price policy, but also the environmental policy leads in a relative sense to exactly the same results for all three farms. This could be expected as far as the use of variable production factors is concerned. However, this holds also for the use of fixed production factors, showing that the differences in economies of scale between the farms are not big enough to justify differences in investments. Consequently, a more detailed comparison of the results of the small and the large farm with the average farm adds nothing to the results that were presented in section 4.1.

Differences in intensity because of different areas

Comparison of the extensive farm (B) with the small farm (D) and of the intensive farm (C) with the large farm (E) shows effects of intensity because of differences in area, at a lower and a higher intensity level. Here, the focus is on income. Comparison of environmental results would be a repetition of the comparison of the farms A, B, and C, since environmental results are presented on a hectare basis.

The extensive and the small farm have the same quota, but the area of the small farm is only two-thirds of that of the extensive farm. In spite of the extra area of the extensive farm, the labour income of both farms in the basis situation is almost the same (Figure 4). This means that the returns of the extra area are completely cancelled by the costs. The extra area of the extensive farm is used for keeping extra young stock, for producing grass at a lower N level and for producing and selling a small area of silage maize. Under scenario I and scenario III, in which the environmental policy has little influence, the extra area of the extensive farm leads to an income lower than that of the small farm. This is due to technical change that decreases the need for land to produce roughage for own use. The extensive farm has an advantage when the farms are confronted with the severe environmental policy. Labour incomes differ by NLG 8,000 to 11,000 under scenario II and IV respectively.

The intensive and the large farm have the same quota, but the area of the intensive farm is only three-quarters that of the large farm in the basis situation. The extra area of the large farm is used for keeping more young stock, for growing grass at a lower N level and for producing silage maize which decreases the amount of silage maize that has to be purchased. This results in a labour income that is about NLG 10,000 higher than the labour income on the intensive farm. The difference in labour income decreases slightly under scenario I, but it increases under the scenarios II to IV. Under scenario IV it nearly reaches NLG 19,000.

Comparing these results, it appears that in an intensive situation (farm C) an increase of the area leads to higher income while no increase of income is realized when the area is increased in a less intensive situation (D). Mainly responsible for this difference is the shortage of grass in the summer ration of the dairy cows in the intensive situation. To minimize this shortage, grass is grown at a high N level while roughage and concentrates are purchased to make up the ration. All of these are expensive measures. Apparently, there exists an optimal farming intensity given an available milk quota beyond which further extensification has no positive effect on farm income. Shadow prices of land indicate that this intensity lies between the intensity of farm D and that of farm B. Technical change tends to increase this optimal intensity while severe environmental legislation tends to decrease it.

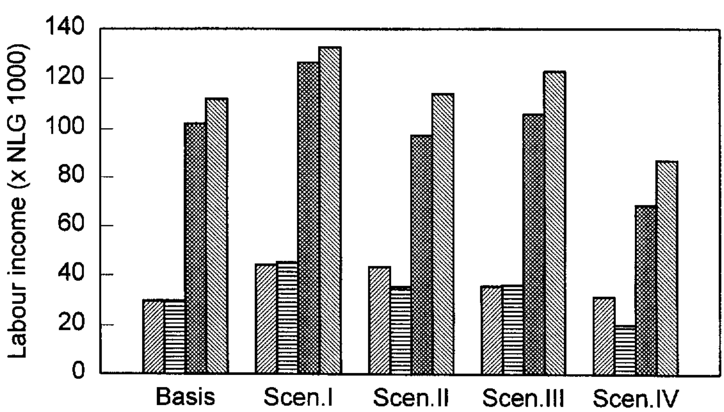

Figure 4. Labour income for the extensive (▨), the small (☰), the intensive (▩) and the large (▧) farm in the basis situation and under four scenarios.

Sensitivity analysis

Here it is assumed that the increase in grass production at an N-supply of 500, 400, 300, 200 and 100 kg/ha is 100, 85, 70, 55 and 40% respectively of the yearly used in the previous situations. Table 7 shows some of the differences for the average farm. Under scenario I, lower grass production is for the most part compensated by an area of grassland that is 1.9 ha larger. Instead of selling 1.4 ha of silage maize, now 0.6 ha has to be purchased, which makes a total difference of 2.0 ha. Labour income is NLG 2,253 lower. Of the environmental losses, only N losses are substantially higher, which is the case for all scenarios. N leaching differs with the area of silage maize and the N level on grassland. All other differences are small. Under scenario II, lower grass production is compensated for by a higher N level on grassland and by a larger area of grassland. Due particularly to the higher N level, NH_3 emission is higher and levies have to be paid. As a consequence, labour income is NLG 2,677 lower. The greatest difference in labour income arises when total milk production is raised to a high level (i.e. under scenario III). In that case, lower production of grass is compensated fully by higher roughage purchases. Under scenario IV, the difference in labour income is NLG 3,325. To balance feed requirements and feed supply, the number of dairy cows is 1.7 lower, the area of grassland is slightly larger and the N level on grassland is higher.

From these results, it can be concluded that differences in income are bigger when pressure from environmental legislation is higher (scenario II) or when production becomes more intensive (scenario III). Hence, intensive farms loose more than extensive farms when technical change is lower than expected.

Table 7. Differences in results for the average farm due to a lower increase in grass production.

	2005			
	Price support policy		Two price system	
	Mod. env. policy	Sev. env. policy	Mod. env. policy	Sev. env. policy
Technical results:				
– area of grassland (ha)	+ 1.9	+ 1.2	+ 2.3	+ 0.4
– N level on grassland (kg/ha)	0	+ 15	0	+ 14
– area of silage maize purchased (sold)[1]	+ 2.0	+ 1.1	+ 2.1	0
Labour income (NLG)	– 2253	– 2677	– 3388	– 3325
Environmental results:				
– N losses (kg N/ha)	+ 15.2	+ 20.8	+ 17.7	+ 16.4
– NH_3 emission (kg NH_3/ha)	0	+ 0.4	– 0.2	– 0.6
– N leaching (kg N/ha)	– 1.6	+ 0.6	– 2.4	+ 1.3
– P_2O_5 losses (kg P_2O_5/ha)	– 0.9	– 1.0	+ 4.8	– 1.0

[1] A positive value means that more silage maize is purchased or that less silage maize is sold.

Discussion

Assumptions

The analysis is conducted using 1992 base prices and assuming all prices will not be affected by inflation. An overview of the prices of the last fifteen years for the main output (i.e. milk) and for the main inputs (i.e. concentrates and fertilizer) shows that existing inflation did not structurally affect these prices (Anonymous, 1995b). The assumption that also in the future prices will not be affected by inflation means that calculated labour income for 2005 can be considered nominal income. When comparing income for 1992 and 2005 the effect of inflation should be kept in mind. Any inflation in the period 1992–2005 leads to a lower real value of the calculated labour incomes for 2005.

Technical change as it is used in the scenarios includes increase of production without quality changes. Especially in roughage production, quality changes are hard to asses. In roughage production quality is defined by the amount of energy per kg dry matter. If dry matter intake capacity of the dairy cow is limiting dry matter intake from roughage, then increase of quality results in a higher proportion of roughage in the ration and consequently in lower concentrate costs. However, from the results it appears that dry matter intake capacity only has a small influence on the summer rations. Quality of milk is defined by the fat and protein content of milk. With a milk quota that is partly based on fat content of the milk and with a price for milk based on fat and protein content it is attractive to decrease the fat/protein ratio in the milk. An increase of the protein content of milk at a given fat content results in a higher milk price and in higher feeding costs. On balance, labour income will increase. However, the room for such a change is small, as fat and protein content of milk are positively correlated (Wilmink, 1987).

From a comparison of the results under the different scenarios with those in the basis situation it appears that in general the average fertilizing level per hectare decreases. This lower fertilizer use per hectare results in a substantial decrease in demand of fertilizer at national level. Given normal market reactions, this could lead to a decrease in the price of fertilizer, which would have a positive effect on labour income of all farms. However, since fertilizer is a commodity that has a relatively open market and considering the small Dutch share in total demand for fertilizer (Heijbroek & De Kater, 1993), the price reductions due to a decreased Dutch demand for fertilizer will be small. Furthermore, it appears that purchase of concentrates per farm increases. At the national level, the increase in the amount of concentrates purchased at the farm level is partly compensated by the lower number of dairy farms. Nevertheless, higher milk production per cow requires a higher proportion of concentrates in the ration. With a given national milk quota, this leads to higher use of concentrates in dairy farming at the national level. It is possible that this will lead to higher prices of concentrates. In the eighties, a substantial reduction in the use of concentrates caused by introduction of the quota system led to a fall in prices of concentrates. Higher prices of concentrates obviously have a negative effect on farm income. This effect will be bigger under scenario III if total milk production is raised to a high level and it will be higher on intensive and larger farms that rely more on the use of concentrates. Finally, it appears that on an intensive farm purchase of roughage decreases while on an extensive farm, that has little opportunities to utilize its surplus area, supply of roughage increases. It can be expected that this will have a price depressing influence. However, this influence could very well be tempered by arable farmers that exchange production of silage maize for production of grains. For intensive farms, a lower price for roughage means an increase in labour income while for extensive farms it decreases labour income. Taken together, intensive farms can compensate a higher price for concentrates by a lower price for roughage purchased. The negative consequences for extensive farms could be eased by growing crops that have the same fodder characteristics as concentrates. However, the costs of these concentrate-replacing crops must not be too high. Fodder beet, for example, which has feeding characteristics similar to concentrates is not taken up in the farm plan because of the high costs of harvesting.

The price of milk is a main determinant of the revenues and consequently of the labour income of the farm. In addition to the EU price support, the milk price depends on a number of uncertain factors like the US dollar exchange rate, demand and supply of milk and milk products on the EU market and the world market price. The price used in the scenarios (NLG 78.50 per 100 kg) is based on the 1992/93 price. Since 1992/93, the price has declined. For the results, a decrease of the high milk price by NLG 1 per 100 kg would mean a decrease of income by NLG 2270 for the extensive and the small farm under scenario III and IV, up to a decrease of NLG 4820 for the intensive and the large farm under scenario I and II. For the average farm a price decrease of NLG 4.70 would completely offset the positive income effects due to technical change. In all these cases the milk price does not influence the optimal plan of the farm, as producing milk is by far the most profitable production possibility of the farm.

The replacement rate of dairy cows in the model is based on the actual average replacement rate in 1992 of 36% (Berentsen *et al.*, 1996b). This rate is used for 2005 also because it is assumed that the yearly increase in milk production is partly caused by this high replacement rate. Decreasing the amount of young stock on the farm is often advocated as a means to decrease nutrient losses (Aarts *et al.*, 1992). Under a severe environmental policy and for intensive farms, a decrease in the number of young stock without a decrease in milk production per cow would have a positive influence on labour income, on nutrient losses in general, and on NH_3 emission in particular. When using the two-price system a decrease in the replacement rate would be beneficial for all farms, since a greater part of the stable capacity can be used for dairy cows and total milk production can be raised to a higher level.

Results

The results show that dairy farms can at least maintain their income at the level of 1992 under most of the scenarios. The only exception counts for more intensive farms in case of the scenario that combines the severe environmental policy with liberalization of milk production. Comparison of the consequences of the complete scenarios with the results of the scenario studies that were mentioned in the introduction shows that in all studies technical change has an increasing effect on income whereas environmental legislation has a decreasing effect on income.

Concerning the aspect of intensity, comparison with the findings of other studies is possible. From the results of this study it appears that income differences between intensive and extensive farms tend to increase as a result of technical change. However, environmental policy and liberalization of milk production have a stronger decreasing effect on income differences. As far as environmental policy is concerned this is in line with findings of Van de Ven (1996). Based on model calculations she reports a decrease in the optimal animal density in dairy farming as a consequence of the introduction of environmental legislation. This means that in terms of income, intensive farms suffer more from environmental legislation than extensive farms. That the stronger position of intensive dairy farms decreases in case milk production is liberalized is also reported by Oskam (1996). He concludes that, although the initial situation for extensive dairy farms is weaker than for intensive farms as far as income is concerned, the perspectives for extensive farms get closer to the perspectives for intensive farms when the quota system is relaxed.

Conclusion

Technical change up to 2005 has a positive influence on labour income as well as on nutrient losses. The increase of labour income is higher for farms with a higher total milk production in the basis situation. A severe environmental policy has a negative effect on labour income. This effect is bigger for farms with a higher intensity, as these farms have to take more measures to comply with governmental policy. Replacement of the price support policy for milk by a two-price system with a high price for a restricted amount of milk and a low price for an unrestricted amount of milk has negative consequences for labour income. Also in this case intensive farms loose more income than extensive farms.

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