Socio-economic aspects of automatic milking

Socio-economic implications of automatic milking systems

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Information

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Socio-economic implications of automatic milking systems

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Abstract

The objective of this deliverable is to analyze the economic and social implications of automatic milking (AM) at the farm level. For this, a farm level survey was designed. A questionnaire has been designed to capture the characteristics and motivations of AM farmers, farm characteristics (such as farm size, grazing system, etc.) and the implications of the introduction of an AM-system. Addresses of AM farmers were assembled with the assistance of the AM manufacturers. A random sample was then drawn from the frame to yield a sample of 13 AM users in Belgium, 57 in the Netherlands, 13 in Denmark and 24 in Germany, totalling to 107 respondents. Farmers were interviewed face-to-face in November 2001 - November 2002. From a subset of 43 of these farmers, we also acquired the accounts or part of the accounts through their bookkeeping agencies. AM farmers report an average reduction of labour use of 20-21%. When hired labour is employed, it is laid off. When there is no hired labour, AM farmers use the free time primarily for non-productive purposes, that is, to spend more time on leisure and with the family. As a result, most AM users report that the quality of life of their family has increased. We have not found widespread evidence of any negative implications, such as increased stress. To assess the financial implications of AM, we simulated a set of typical farms. These typical farms are not average farms, but represent a significant number of dairy farms in a region in terms of size, forage and crops grown, livestock systems, labour organisation and production technology used. We consider a 68-cow farm in Germany and an 80-cow farm in Belgium that may invest in a 1-box system, and a 90-cow farm in the Netherlands and a 150 cow-farm in Denmark that may invest in a 2-box system. For the typical farms in Belgium, Denmark and the Netherlands investing in an AM-system is profitable if income per hour of family labour is used as an index of profitability. Income from the dairy enterprise only increases for the Danish farm, while profit from the dairy enterprise increases for the Belgian and the Danish farm. The results are particularly sensitive to assumptions on investment costs and labour reduction.

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1 Introduction

The objective of this deliverable is to analyze the economic and social implications of automatic milking (AM) at the farm level. For this, a farm level survey was designed. A questionnaire has been designed to capture the characteristics and motivations of AM farmers, farm characteristics (such as farm size, grazing system, etc.)[1] and the implications of the introduction of an AM-system. Addresses of AM farmers were assembled with the assistance of the AM manufacturers. The initial frame consisted of 28 farmers in Belgium, 414 in the Netherlands and 95 in Germany.[2] In principle, only farmers who installed an AM-system between 1998 and 2001 were retained. A random sample was then drawn from the frame to yield a sample of 13 AM users in Belgium, 57 in the Netherlands, 13 in Denmark and 24 in Germany, totalling to 107 respondents (see table 1). The surveys were carried out using subcontractors[3], except for Belgium. Farmers were interviewed face-to-face in November 2001 – February 2002 in Belgium, in February – May 2002 in the Netherlands, in October – November 2002 in Germany and in September – November 2002 in Denmark. From a subset of 43 of these farmers, we also acquired the accounts or part of the accounts through their bookkeeping agencies.

Table 1. Sample, frame and population (2001)

	Sample	Initial frame	Population
Belgium (B)	13	28	35+
The Netherlands (NL)	57	414	510+
Denmark (DK)	13	na	250+
Germany (D)	24	95	300+
Total	107	562	1100+

All results in the next sections are reported for each country individually (B = Belgium, NL = The Netherlands, D = Germany and DK = Denmark) and the total for the four countries. Unless indicated otherwise, figures are percentages of the sample, either per country or in total.

This deliverable is further split up in two parts. The first part covers the implications of automatic milking on farm management and on the quality of life of the farmer. These results are considered first, as the assumption of how farm labour changes as a result of the introduction of an AM-system is critical to how the economic results change. The second part investigates the financial implications of AM using simulation models for the four countries. Simulation results are confronted with the results of farms from which the accounts were acquired.

[1] The motivations and characteristics of AM farmers were reported in deliverable D2 (Meskens and Mathijs, 2002).

[2] In Denmark, the frame was not the list of addresses supplied by the manufacturers, but the list of AM farmers at the Danish Agricultural Advisory Centre.

[3] These were Wageningen University in the Netherlands, the Danish Agricultural Advisory Centre in Denmark and Global Farm in Germany.

2 Implications for farm management and the quality of life

2.1 Implications for herd size and grazing strategy

Although we see some small movements between different size classes, average herd size is hardly affected by adoption of an AM-system. Average herd size decreases in the Netherlands, while overall it increases with only 0.5 % (table 2).

Table 2. Herd size before and after the introduction of an AM-system

	B	NL	D	DK	Total
Before					
0-40	7.7	-	-	-	0.9
40-70	30.7	31.6	34.8	7.1	28.9
70-100	38.5	43.8	34.8	42.8	41.1
100-130	7.7	14.0	30.4	14.7	16.8
130-160	7.7	4.0	-	35.7	8.4
160-190	7.7	1.7	-	-	1.8
190-220	0.0	3.5	-	-	1.8
Average	81.1	86.0	81.3	107.5	87.2
After					
0-40	7.7	-	-	-	0.9
40-70	23.1	27.1	37.5	8.3	28.9
70-100	38.5	52.1	29.2	41.7	41.1
100-130	15.4	12.5	29.2	33.3	16.8
130-160	7.7	4.2	4.1	16.7	8.4
160-190	7.7	2.1	-	-	1.8
190-220	-	2.1	-	-	1.8
Average	82.3	84.6	81.5	107.7	87.7

Before AM, most farmers either applied unlimited grazing or grazing for 8 to 12 hours (table 3). A large proportion of farmers has changed grazing strategy after adoption, shifting primarily towards in stable summer feeding: while only 15% of all farmers where practicing this strategy before AM, the share increased to 52% after adoption.

AM farmers generally disagree with the statement that the contact between the farmer and his animals has decreased (table 4), although a majority of farmers reports to spend more time observing the cows (table 5).

Table 3: Grazing system before and after introduction of an AM-system

	B	NL	D	DK	Total
Before introduction					
Unlimited grazing	69.2	15.8	30.4	35.7	28.0
8 to 12 hours	23.1	52.6	34.7	21.4	41.1
Less then 4 hours	-	-	4.3	7.1	1.8
2 x less then 4 h	-	1.7	-	-	0.9
Zero-grazing	-	4.0	4.3	7.1	4.7
Summer feeding	7.7	12.3	17.4	28.6	14.9
walking out	-	1.7	8.7	-	2.8
2 x 8 hours	-	8.8	-	-	4.7
After introduction					
Unlimited grazing	38.4	5.3	8.3	7.7	10.3
8 to 12 hours	23.1	35.1	-	15.4	23.4
Less then 4 hours	-	-	8.3	15.4	3.7
2 xless then 4 h	15.4	1.8	-	-	2.8
Zero-grazing	0.0	8.8	4.2	7.7	6.5
Summer feeding	23.1	42.1	58.3	46.2	43.9
walking out	-	3.5	20.8	7.7	7.5
2 x 8 hours	-	3.5	-	-	1.9

Table 4. Results of the statement "After the purchase of an AM-system the contact between the farmer and his animals decreases" (%)

	Totally not agree	Partly not agree	No change	Partly agree	Totally agree	Average score
B	61.5	7.7	15.9	-	15.9	2.0
NL	89.3	0.0	1.8	5.4	3.6	1.3
D	50.0	20.8	-	4.2	25.0	2.3
DK	69.2	7.7	-	15.4	7.7	1.8
Total	74.5	6.6	2.8	5.7	10.4	1.7

Table 5. Results of the statement "On an AM farm, farmers need to spend more time observing the cows" (%)

	Totally not agree	Partly not agree	No change	Partly agree	Totally agree	Average score
B	7.7	-	15.9	15.9	61.5	4.2
NL	14.3	3.6	21.4	10.7	50.0	3.8
D	16.7	4.2	12.5	29.2	37.5	3.7
DK	23.1	-	15.4	38.5	23.1	3.4
Total	15.1	2.8	17.9	18.9	45.3	3.8

2.2 Implications for labour

On average, AM farmers reported a 20% saving of total labour on the farm after investing in an AM-system (table 6). The amount of total labour savings of the Belgian farmers (who work more hours than their colleagues from other countries) is the highest (-28%). In Denmark the amount of labour savings is the smallest (-12%). The labour savings specific to the dairy enterprise are higher for all labour (-20%) than for family labour (-16%), which indicates that hired labour is laid off before reducing family labour.

Table 6. Changes in labour (total sample, n=107)

	Before (h/week)	After (h/week)	Change (%)
Family labour allocated to the dairy enterprise			
B	119.82	88.82	-25.87
NL	85.95	72.18	-16.02
D	96.50	77.92	-19.25
DK	66.38	68.42	+3.07
Total	89.56	74.82	-16.46
Total labour allocated to the dairy enterprise			
B	124.55	89.45	-28.18
NL	94.59	77.34	-18.24
D	109.54	84.63	-22.74
DK	96.04	84.99	-11.51
Total	101.47	81.37	-19.81
Total farm labour			
B	125.32	90.23	-28.00
NL	95.51	77.03	-19.35
D	126.48	101.00	-20.15
DK	96.50	84.99	-11.93
Total	105.02	84.36	-19.67

Table 6 also shows that the division of labour between family and hired labour is not equal between the four countries. About half of the total labour of Danish farms is hired labour, while in Belgium and the Netherlands this is only a small percentage. In contrast with the other countries, Danish family labour slightly increases after purchasing an AM-system. This is probably due to the fact that many Danish farmers have a full-time employee. When purchasing an AM-system, the employee is dismissed. As not all his working hours are saved by the AM-system, the farm manager and his family have to work a bit more.

As total labour saving on the dairy enterprise almost exactly corresponds with total labour saving on the entire farm, we can conclude that most AM farmers use the additional time off-farm (see section 2.4). However, a small share of the surveyed farms have taken the opportunity to increase or decrease the size of their dairy farm. As a result, the results in table 6 may be biased. Hence, we subdivided the sample into three herd size change categories[4]:

[4] Excluding 13 farms (12.0% of the sample) for which no information on the change in herd size was available.

- Group(-) are farmers whose dairy herd size is decreased after adoption (1.9% of the sample).
- Group(0) (or constant farms) includes farmers whose dairy herd size remains constant within a certain range (69.1% of the sample). The range depends on the assumed increase in milk yield, the higher the increase the higher the range.
- Group(+) (or growing farms) includes farmers whose dairy herd size has increased after adoption of AM-system (17.0% of the sample).

The distribution of these groups by country is shown in figure 1.

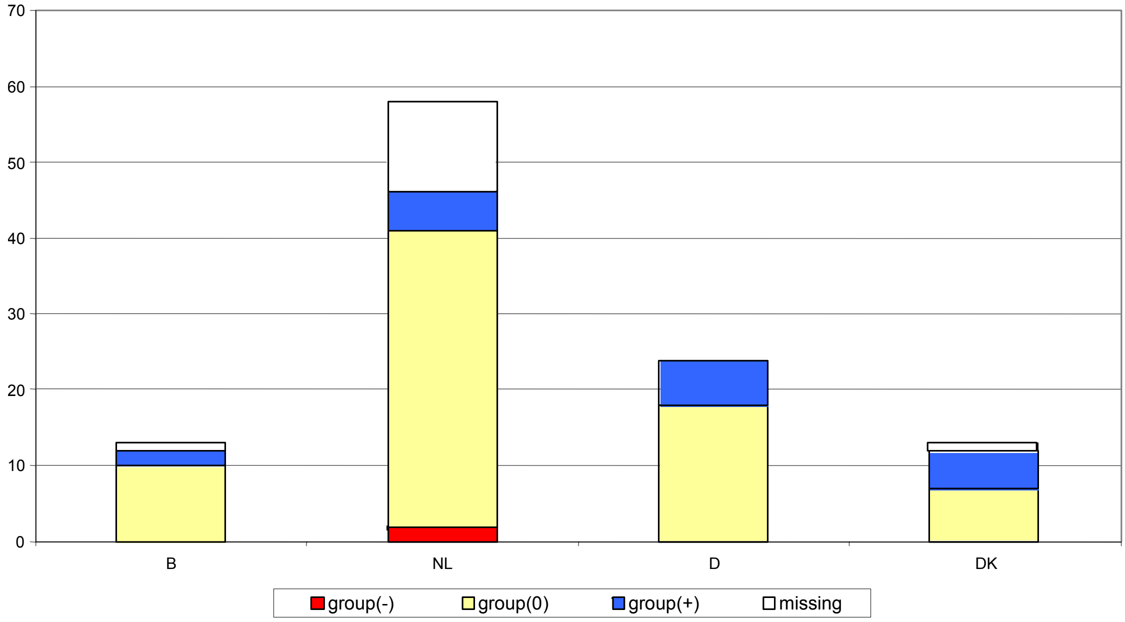

Figure 1. Division of the sample between missing values, and groups according to change in size

In each country, group(0) is by far the largest group: most farmers in the sample do not combine the adoption of an AMS with a change in size of their farms. Only a small percentage of the farms is growing in size when they purchase an AM-system and there are only 2 farms – in the Netherlands – who decrease in size.

Average difference in labour demand before and after the purchase of the AM-system was recalculated for constant farmers only (table 7). Constant farms have an average saving in total farm labour of 22%. This is slightly more than for the whole sample. These results can be expected: farms who grow after investment will use their saved labour to milk more cows, so when they are not included, labour saving will be higher. As the proportion of farms who increase or decrease in size is very small, the differences between table 6 and 7 are rather small.

Table 7. Changes in labour (constant farms only, n=74)

	Before (h/week)	After (h/week)	Change (%)
Family labour allocated to the dairy enterprise			
B	122.70	91.40	-25.51
NL	87.63	71.97	-17.87
D	102.89	81.72	-20.58
DK	62.14	65.00	+4.60
Total	93.67	76.31	-18.53
Total labour allocated to the dairy enterprise			
B	127.90	92.10	-27.99
NL	94.86	75.90	-19.99
D	114.72	88.44	-22.91
DK	93.57	84.07	-10.15
Total	104.03	81.91	-21.26
Total farm labour			
B	128.75	92.95	-27.81
NL	96.91	75.90	-21.68
D	131.99	102.00	-22.72
DK	93.57	84.07	-10.15
Total	109.28	85.33	-21.92

2.3 Implications for health

AM farmers generally think that AM has a positive impact on their physical health: only 6.5 % of the farmers does not agree with the statement that their physical health has improved (table 8). Although differences between countries are minor, Dutch and Danish AM farmers tend to agree more. However, at the same time the farmers disagreeing with the statement are also to be found in these two countries.

Table 8. Results of the statement "my physical health has improved" (%)

	Totally not agree	Partly not agree	No change	Partly agree	Totally agree	Average score
B	-	-	53.8	30.8	15.4	3.6
NL	10.7	-	41.4	8.9	39.3	3.7
D	-	-	37.5	37.5	25.0	3.9
DK	-	7.1	14.3	21.4	57.1	4.3
Total	5.6	0.9	38.3	19.6	35.5	3.8

A positive impact on mental health is less straightforward, although most AM farmers (77%) see no change or an improvement (table 9). German AM farmers agree most with the statement. The state of mental health is further detailed by looking at sleeping quality and stress in the following tables:

- Almost half of the farmers have experienced no change in their sleeping quality since the purchase of the AM-system (table 10). In Germany there are remarkably more farmers who agree with the statement (average score of 3.3).
- Most farmers (75.5%) do not worry about whether the AM-system is working well while they are absent (table 11). Dutch and Danish AM farmers worry less than their Belgian and German colleagues.
- The same country pattern can be found for the statement that the possibility of getting a call related to problems to the AM-system increases stress. Most farmers (79%) disagree with this statement (table 12). Particularly some Belgian and German farmers are stressed in this way. This may be explained by the fact that Belgian and German farmers are more diversified.

Table 9. Results of the statement "my mental health has improved" (%)

	Totally not agree	Partly not agree	No change	Partly agree	Totally agree	Average score
B	15.4	15.4	23.1	30.8	15.4	3.2
NL	19.6	8.9	39.3	17.9	14.3	3.0
D	-	8.3	33.3	33.3	25.0	3.8
DK	14.3	7.1	35.7	35.7	7.1	3.1
Total	14.0	9.3	35.5	25.2	15.9	3.2

Table 10. Results of the statement "my sleeping quality has improved since investing in the AM-system" (%)

	Totally not agree	Partly not agree	No change	Partly agree	Totally agree	Average score
B	15.4	15.4	38.5	30.8	-	2.8
NL	16.4	5.5	50.9	5.5	21.8	3.1
D	8.3	16.7	33.3	25.0	16.7	3.3
DK	21.4	7.1	50.0	7.1	14.3	2.9
Total	15.1	9.4	45.3	13.2	17.0	3.1

Table 11. Results of the statement "When I am absent, I worry about the well-functioning of the AM-system" (%)

	Totally not agree	Partly not agree	No change	Partly agree	Totally agree	Average score
B	38.5	30.8	7.7	7.7	15.9	2.3
NL	75.0	3.6	5.4	8.9	7.1	1.7
D	45.8	20.8	4.2	29.2	-	2.2
DK	53.8	30.8	-	7.7	7.7	1.8
Total	61.3	14.2	4.7	13.2	6.6	1.9

Table 12. Results of the statement "The possibility of being called that there is a problem with the AM-system at every moment puts a lot of stress on me" (%)

	Totally not agree	Partly not agree	No change	Partly agree	Totally agree	Average score
B	46.2	15.9	7.7	-	30.8	2.5
NL	86.0	3.5	3.5	3.5	3.5	1.4
D	33.3	29.2	12.5	25.0	-	2.3
DK	69.2	15.4	-	-	15.4	1.8
Total	67.3	12.1	5.6	7.5	7.5	1.8

2.4 Implications on leisure and social relations

Farmers were asked about their opinion about certain statements that assess how they spend their time before and after AM. As the answers to statements concerning time may be affected by the number of cows before and after investing in the AM-system, we report both the results for all farms and for the three herd size change categories defined in section 3.2.

A first group of statements concern changes in social activities that are still linked to the profession of dairy farmer. Table 13 and 14 show that AM farmers generally do not spend more time in having more contact with other farmers or in attending more meetings: 58% does not have more contact with other farmers, while 79% does not attend more meetings. No significant differences can be found between different herd size change categories. AM enables only 35.5% of the AM farmers to be replaced easily. The answers to this statement are very spread with relative large shares strongly agreeing or disagreeing. This results overall in a neutral to negative result (table 15). Growing farmers tend to see themselves being replaced more easily than constant farmers. This is probably due to the presence of hired labour. Very few farmers (10.5%) actually miss the milking activity (table 16). Most farmers even strongly disagree with this statement. Those who agree with the statement are always constant farmers.

Table 13. Results of the statement "I have more contact with colleagues" (%)

	Totally not agree	Partly not agree	No change	Partly agree	Totally agree	Average score
All farms						
B	-	-	53.8	38.5	7.7	3.5
NL	21.4	-	42.9	16.1	19.6	3.1
D	4.2	4.2	50.0	37.5	4.2	3.3
DK	7.7	7.7	23.1	53.8	7.7	3.5
Total	13.2	1.9	43.4	28.3	13.2	3.3
By herd size change category						
Group(-)	-	-	50.0	50.0	-	3.5
Group(0)	16.2	1.4	47.3	24.3	10.8	3.1
Group(+)	5.6	-	33.3	50.0	11.1	3.6

Table 14. Results of the statement "I can attend more meetings" (%)

	Totally not agree	Partly not agree	No change	Partly agree	Totally agree	Average score
All farms						
B	30.8	7.7	53.8	7.7	-	2.4
NL	44.6	1.8	46.4	1.8	5.4	2.2
D	16.7	-	29.2	41.7	12.5	3.3
DK	15.4	-	53.8	23.1	7.7	3.1
Total	33.0	1.9	44.3	14.2	6.6	2.6
By herd size change category						
Group(-)	-	-	50.0	-	50.0	4.0
Group(0)	32.4	2.7	48.7	14.9	1.4	2.5
Group(+)	33.3	-	33.3	16.7	16.7	2.8

Table 15. Results of the statement "As a result of AM, I can be easily replaced at my farm" (%)

	Totally not agree	Partly not agree	No change	Partly agree	Totally agree	Average score
All farms						
B	30.8	30.8	-	7.7	30.8	2.8
NL	38.6	14.0	17.5	10.5	19.3	2.6
D	25.0	20.8	8.3	20.8	25.0	3.0
DK	15.4	23.1	23.1	23.1	15.4	3.0
Total	31.8	18.7	14.0	14.0	21.5	2.7
By herd size change category						
Group(-)	-	50.0	-	-	50.0	3.5
Group(0)	35.1	18.9	12.2	14.9	18.9	2.6
Group(+)	11.1	16.7	22.2	22.2	27.8	3.4

Table 16. Results of the statement "I miss the milking activity" (%)

	Totally not agree	Partly not agree	No change	Partly agree	Totally agree	Average score
All farms						
B	76.9	7.7	-	7.7	7.7	1.6
NL	75.0	1.8	3.6	1.8	17.9	1.9
D	83.3	8.3	4.2	4.2	-	1.3
DK	83.3	8.3	-	8.3	-	1.3
Total	78.1	4.8	2.9	3.8	10.5	1.6
By herd size change category						
Group(-)	100.0	-	-	-	-	1.0
Group(0)	75.3	5.5	4.1	4.1	11.0	1.7
Group(+)	100	-	-	-	-	1.0

The next set of statements relate to the private sphere of the farmer. Farmers do tend to spend more time on leisure: 62% reports to spend more time on hobbies. The percentages are comparable between the different countries, but also in the different herd size change categories (table 17). AM farmers generally do not spend more time with friends, as the large majority reports no change or disagrees with this statement (table 18). It seems that additional leisure time is primarily spent within the family. This is also independent of herd size change category. This result is confirmed by the fact that the overwhelming majority of AM farmers (86%) spends more time with their family (table 19). Differences between countries and herd size change categories are rather small. Finally, two thirds of the farmers say the quality of life of their family has improved (table 20). The Dutch farmers see their quality of life least improved, but the differences are minor. Constant farmers see quality of life improved more than growing famers.

Table 17. Results of the statement "I have more time for hobbies" (%)

	Totally not agree	Partly not agree	No change	Partly agree	Totally agree	Average score
All farms						
B	-	-	30.8	38.5	30.8	4.0
NL	8.9	1.8	30.4	21.4	37.5	3.8
D	-	-	26.1	47.8	26.1	4.0
DK	14.3	-	35.7	35.7	14.3	3.4
Total	6.6	0.9	30.2	31.1	31.1	3.8
By herd size change category						
Group(-)	-	-	-	50.0	50.0	4.5
Group(0)	6.8	1.4	29.7	27.0	35.1	3.8
Group(+)	5.6	-	27.8	50.0	16.7	4.0

Table 18. Results of the statement "I have a larger circle of friends" (%)

	Totally not agree	Partly not agree	No change	Partly agree	Totally agree	Average score
All farms						
B	-	-	69.2	23.1	7.7	3.4
NL	39.3	-	57.14	-	3.6	2.3
D	4.2	-	83.3	8.3	4.2	3.1
DK	7.7	7.7	76.9	7.7	-	2.8
Total	22.6	0.9	67.0	5.7	3.8	2.7
By herd size change category						
Group(-)	-	-	100.0	-	-	3.0
Group(0)	24.3	-	64.9	6.8	4.1	2.7
Group(+)	22.2	-	66.7	5.6	5.6	2.7

Table 19. Results of the statement "I have more possibilities to spend time with my family"(%)

	Totally not agree	Partly not agree	No change	Partly agree	Totally agree	Average score
All farms						
B	-	7.7	7.7	53.8	30.8	4.1
NL	3.6	1.8	5.5	30.9	58.2	4.4
D	-	-	12.5	50.0	37.5	4.3
DK	7.1	7.1	14.3	21.4	50.0	4.0
Total	2.8	2.8	8.5	36.8	49.1	4.2
By herd size change category						
Group(-)	-	-	-	-	100.0	5.0
Group(0)	1.4	4.1	10.8	37.8	45.9	4.2
Group(+)	5.6	-	5.6	38.9	50.0	4.3

Table 20. Results of the statement "the quality of life of our family has improved" (%)

	Totally not agree	Partly not agree	No change	Partly agree	Totally agree	Average score
All farms						
B	-	7.7	23.1	46.2	23.1	3.8
NL	9.3	-	37.0	22.2	31.5	3.7
D	-	-	8.7	43.5	47.8	4.4
DK	7.1	7.1	7.1	50.0	28.6	3.9
Total	5.8	1.9	25.0	33.7	33.7	3.8
By herd size change category						
Group(-)	-	-	50.0	-	50.0	4.0
Group(0)	6.8	1.4	23.0	29.7	39.2	3.9
Group(+)	5.6	-	27.8	55.6	11.1	3.6

3 Financial implications

3.1 Methodology

Usually, the profitability of an automatic milking (AM) system is assessed by calculating its net present value (NPV), i.e., the discounted sum of returns and costs. If NPV>0 the AM-system is profitable. Further, if the NPV of the investment is higher than the NPV of a traditional milking parlour, the former is preferred (Dijkhuizen et al., 1997; Cooper and Parsons, 1999; Hyde and Engel, 2002). Such a simulation can be applied to representative farms (Dijkhuizen et al., 1997; Hyde and Engel, 2002) to make general statements or to real farms (Cooper and Parsons, 1999). The problem with representative farms is that they are usually based on statistical averages and that they usually do not exist in reality. The problem of using real farms is that results are limited to these farms, which may be very specific. Moreover, previous evidence in the formal literature is limited to the Netherlands (Arendzen and van Scheppingen, 2000; Dijkhuizen et al., 1997), the USA (Dijkhuizen et al., 1997; Hyde and Engel, 2002) and the UK (Cooper and Parsons, 1999). Critical factors affecting the profitability of automatic milking compared to conventional milking identified by these studies are milk yield response, changes in labour requirements (and wage rates), quota prices and the lifetime of an AM-system.[5]

We adopt a mixed approach by using 'typical' farms. These are virtual farms that are based on existing farms using three sources of data: national statistics, a panel of farmers and expert knowledge. Typical farms are designed to be representative for a certain herd size group and production system. Moreover, they are established following a common methodology coordinated in the International Farm Comparison Network (IFCN). Results only hold for these typical farms and cannot be generalised. This paper starts from four typical farms in four European countries (Belgium, Denmark, Germany and the Netherlands). Changes due to automatic milking are based on data found in the literature and on real farm data from the survey.

To investigate the implications of AM on the economics of the farm in four countries (DK, B, NL, D), simulations are carried out using typical farms for each of the countries developed in the framework of the International Farm Comparison Network (IFCN). The model is set up to deliver typical farms within a country or within a specific region of the country. The virtual farms are based on existing farms which are selected in term of size, production system and contribution to the total production of the country. Sources of data used to set up the typical farms include a panel of farmers, national available statistics and expert knowledge of IFCN-researchers and local advisors.

TIPI-CAL (Technology Impact and Policy Impact Calculations), the Excel-based simulation model incorporating physical and economic data of the IFCN, is used to assess the impact of investing in an AM-system. The model simulates typical farms for up to 10 years in the future. Input data include farm data, projections of prices, costs and yields, farm strategies. The model provides a profit and loss account, a cash flow statement and a balance sheet for each year of simulation (dynamic recursive). The major advantage of using this approach is that a common framework is imposed on all countries. The farms selected for simulation include the typical farms D-68, B-80, NL-90 and DK-150[6], where the numbers refer to initial herd size. A number of selected parameters characterizing these farms is provided in table 21. The Belgian and German farms are assumed to purchase a one-box system; the Dutch farms

[5] Refer to Meskens et al. (2001) for a recent overview of the literature.

[6] Theoretically, also other typical farms could have been included, but it was decided to consider only one typical farm per country due to limitations in resources.

are assumed to invest in a two-box system and the Danish farms are assumed to invest in a 3-box system. Herd sizes are assumed to adjust to optimize the use of the AM-system.

Table 21: Characteristics of the initial farms, one year before investment

	B	D	NL	DK
Herd size (number of cows)	80	68	90	150
Land (ha)	50	90	45.1	140
Milk yield (t/cow/year)	7.2	7.5	8.3	8.5
Total labour (hours/year)	5500	5200	4810	5450
Income (€/hour)	20.92	14.12	31.76	8.06
Cash flow (€/hour)	23.98	20.99	38.53	30.85

3.2 Base assumptions

In the base analysis we assume that a farmer must choose between an AM-system and a traditional milking parlour. The assumptions from the base analysis originate from various sources. All figures are tax and VAT excluded.

3.2.1 Revenues

With an AM system the milking frequency can be higher than with the traditional milking parlours. Milk production per cow is found to increase from 6 to 25 % (Hogeveen et al., 2001). We will consider an increase of 6 % in the base analysis, but only in the year after the adoption. In the year of investment, the same yield as in the traditional parlour is assumed. The higher milk yield means that an AM farm can milk the same quotum as a conventional farm with less cows. Generally, a reduction in milk price is assumed following a protein and butterfat percentage decline. However, as the impact on price is relatively small (1-2%) and also other factors may influence price received, we assume this change to be negligable.

3.2.2 Investments and complementary costs

The investment costs are an important issue to consider in the decision between an AM-system and a traditional parlour. The costs of a traditional parlour depend highly on the degree of automation. We consider a parlour with a rather high degree of automation – since this decision was made in disadvantage of an AM-system – with a price of 50,000 € in Belgium and Germany, 70,000 € in the Netherlands and 90,000 € in Denmark. The price of an AM-system depends on the way cows are recognised in the system and on the software. We consider a price of 128,000 € for a 1-box system, 220,000 € for a 2-box system and 310,000 € for a 3-box system. We assume that the old barn does not have to be replaced, but that only some adaptations will be necessary (6,273 € for the conventional parlour and 7,000 € for the AM-system). Furthermore the farmer needs to build a new milking stable. The milking stable for a conventional parlour costs 26,073 € in Belgium and Germany and 36,073 euro in Denmark and the Netherlands. For an AM farmer it is 11,000 € for a 1-box system and 20,000 € for a 2-box system and 3-box system. Both the AM-system and the traditional system are depreciated linearly over 10 years (Cooper and Parsons, 1999). Interest rates used are specific to country and year.

The more automated a dairy farmer becomes, the more energy will be used on the farm. Klungel et al. (2000) found that on an AM farm there is a 42.3 % increase in the use of electricity. We will consider an increase of 40 %. In the same investigation, Klungel et al.

found that the use of water on a AM farm was only 1.5 % higher than on a comparable traditional farm. In our simulation the use of water on the traditional farm is the same as on the AM farm.

3.2.3 Livestock costs

Breeding, veterinary and medicine costs are supposed to be the same on both farms. Disinfection costs are slightly higher on a conventional farm. This is, among others, due to the fact that a conventional parlour is bigger than an AM-system. We assume that on the traditional farm disinfection costs are 25 % higher than on the AM farm. Costs for milk control are also the highest on the traditional farm. A traditional farm needs an external controller, such that we assume a difference of 20%. Finally differences in other livestock costs such as bedding, insecticide, earmarks are negligibly small.

When the milk production increases, there has to be a corresponding increase in energy intake. Cooper and Parsons (1999) use the following formulas to calculate the concentrate intake (K) and the roughage intake (R) – where K and R are expressed as kg dry matter per cow – as a function of the milk yield (Y): $K = 0.339\ Y - 340$ and $R = 0.156\ Y + 3528$. Following these formulas, on the AM farm there is a higher use of concentrates per cow because the milk yield is higher. Furthermore, concentrates are used as a mean to tempt cows to come to the AM-system. Even though this effect can be partly neutralised by the fact that the AM farm can milk the same quotum with less cows, in most of the cases the costs for concentrates will be the highest on the AM farm. Furthermore, an AM farm uses often concentrates that are protein-richer; this because on an AMS farm there is less grazing and more silage intake. For the simulation, we only used the exact formulas of Cooper and Parsons on the Dutch and German farms since these were the only typical farms where feed is expressed as kg dry matter per cow per year. In the other two countries feed input in the typical farm was simply expressed as tons per year, including feed not only for dairy cows but also for dry cows, heifers and calves. In this case we interpolated the formulas in the best possible way to indicate the difference in feed input between a traditional and an AM farm.

3.2.4 Labour

The reduction in labour demand is one of the most often mentioned advantages of an AM-system. To what extent labour demand will be reduced is difficult to say and depends on the farm characteristics and on the strategy of the farmer. In this respect, the choice of grazing system and cow traffic are very crucial. We will take a labour reduction of 21%, which is the average labour saving by farms that have kept their herd size constant within a certain range (table 7). This is lower than the 2.6 hours per day saving assumed by Dijk et al. (1997) which approximately equals a 26-28% reduction. Quartile values for the distribution of labour savings (-7% and -33%) are used in the sensitivity analysis. As in Denmark and Germany not all labour is family labour, we assumed that the farmer will reduce hired labour before reducing family labour.

3.3 Base results

The following parameters are investigated and reported in table 22: income, income per unit of family labour, income per kg milk, cash flow, cash flow per unit of family labour, cash flow per kg milk and profit. All parameters are reported five years after investment, for then a relative steady state is reached. Income equals revenues minus costs except family labour and is a measure for the profitability of the farm, independent of how the investment was financed (loan or equity). Cash flow is farm income plus depreciations, changes in inventory and capital gains, and reflects the cash position of the farm. Profit or loss is income minus family labour valued at opportunity cost (country-specific). We also calculated the net present value (NPV) of income over 7 years assuming an opportunity cost of capital of 5%. We could not calculate the NPV over 10 years as investment was done in the second or third year of the simulation and the software only simulates 10 years. It must further be noted that the NPV does not take into consideration the potential income of the labour saved.

Investing in AM results in higher income per unit of family labour in Belgium (+15.36%) and the Netherlands (+5.19%), but not in Germany (-14.26%) and Denmark (-37.04%) (see table 22 for absolute figures and table 24 for relative figures). Expressed per unit of milk produced, income decreases in all cases. Figure 2, 3, 4 and 5 show how income per unit of family labour and cash flow per unit of family labour evolve. In Belgium, the investment is made in 2002 and income per unit of family labour is already higher for the AM-system in 2003 (figure 2). The income difference increases over time to the advantage of the AM-system. In Germany, the investment is made in 2001 and income per unit of family labour of the AM-system never surpasses income of the traditional parlour (figure 3). In the Netherlands the investment is made in 2002 and is followed by a sharp decrease of income per unit of family labour, but not of cash flow per unit of family labour (figure 4). This is due to the drastic change in herd size. Income of the AM-system surpasses income of the traditional parlour in the next year, but the difference is and remains relatively small. In Denmark, the investment is made in 2003 (figure 5). Income in the AM-system starts to be higher only in 2005. Again, the difference is and remains to be rather small.

Looking at absolute figures (i.e., not expressed per unit) yields a somewhat different picture. This is because the alternative use of the labour saved is not taken into account. However, the previous section has shown that labour saved is primarily employed for non-productive uses. Income decreases in all countries, while profit increases in Belgium. The NPV is always lower for AM compared to the traditional parlour, except for Belgium (table 23).

Table 22: Characteristics of the farms, five years after investment

	B	D	NL	DK
Traditional parlour				
Herd size (number of cows)	80	68	128	150
Land (ha)	50	90	64	140
Milk yield (t/cow/year)	7.6	8.9	9.0	9.3
Total labour (hours/year)	5500	5200	5850	5450
Income (€/hour)	17.25	11.15	38.32	18.60
Cash flow (€/hour)	22.30	19.90	43.89	49.00
Income per kg milk	0.16	0.09	0.19	0.04
Cash flow per kg milk	0.20	0.16	0.22	0.11
Income (€)	94,888	53,541	224,174	55,794
Profit/loss (€)	12,797	-24,659	99,152	12,828
AM-system				
Herd size (number of cows)	74	64	120	142
Land (ha)	50	90	64	140
Milk yield (t/cow/year)	8.3	9.4	9.6	9.8
Total labour (hours/year)	4345	4108	4621	4305
Income (€/hour)	19.90	9.56	40.31	11.71
Cash flow (€/hour)	27.30	21.32	52.04	49.28
Income per kg milk	0.14	0.06	0.16	0.03
Cash flow per kg milk	0.19	0.14	0.21	0.11
Income (€)	86,464	39,629	186,275	35,126
Profit/loss (€)	21,612	-27,297	97,518	-7,840

Table 23: Net present value of profits for the first seven years, in euro

	B	D	NL	DK
Traditional parlour	193,117	-125,367	207,070	169,088
AM-system	226,945	-149,998	121,383	21,531

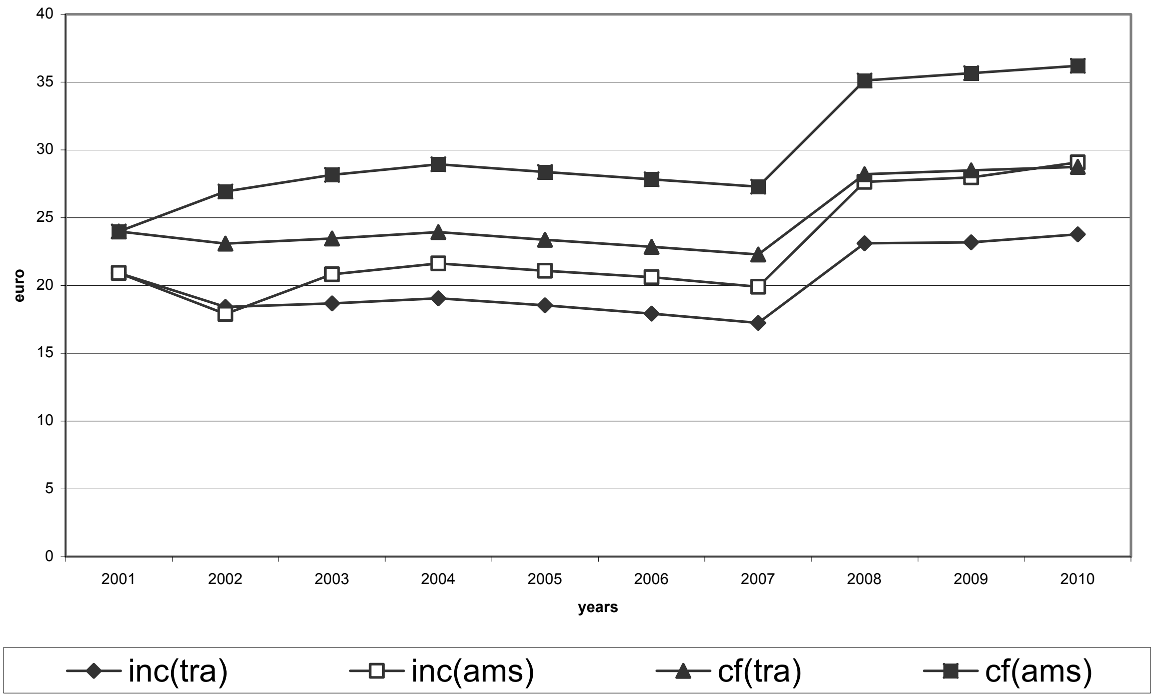

Figure 2: Evolution of income and cash flow, both per unit of family labour, Belgian typical farm

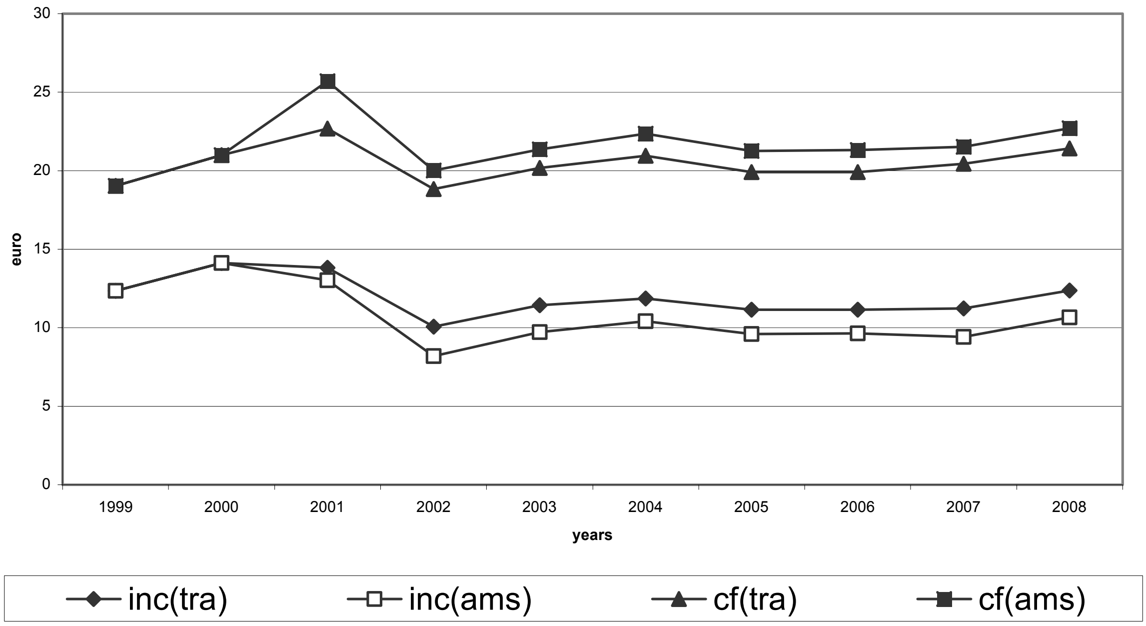

Figure 3: Evolution of income and cash flow, both per unit of family labour, German typical farm

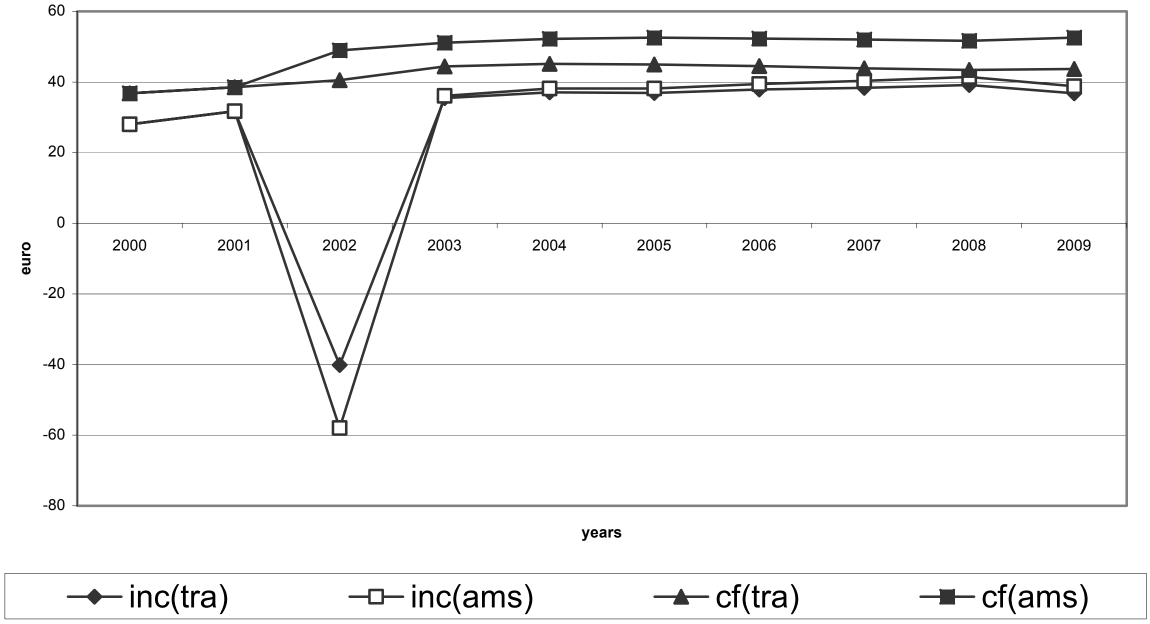

Figure 4: Evolution of income and cash flow, both per unit of family labour, Dutch typical farm

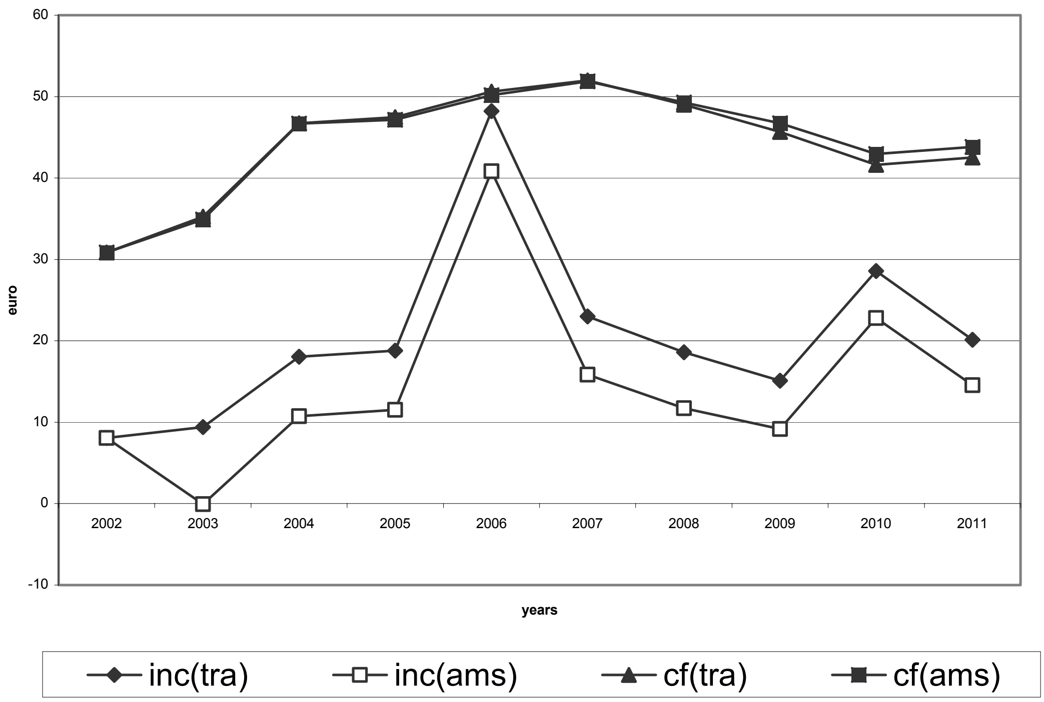

Figure 5: Evolution of income and cash flow, both per unit of family labour, Danish typical farm

3.4 Sensitivity analysis

We have investigated the sensitivity of our results to three parameters: milk yield (+12%, +18% and +24%), investment costs for an AM-system (10% lower and 10% higher) and labour (-7% and -33%). Note that a sensitivity analysis of 10% higher investment costs is equivalent with a 9 year (instead of 10) depreciation period, while a 10% lower investment cost could be the result of non-zero salvage value. We report the impact on income per unit of family labour and cash flow per unit of family labour, both five years after investing, and net present value for seven years (table 24).

The sensitivity analysis of yield changes provides somewhat non-intuitive results: farms with yield increases of 12, 18 and 24% have in most of the cases a lower income than the AM farm in the base simulation. According to our assumptions, all farms keep quotum constant, so they adjust their herd size according to the change in milk yield. As a result, farms with a higher increase in yield will not produce more, so total farm return will not increase. The change in total farm input is ambiguous. Fixed costs will not change as the change in size is too small. Variable costs have a tendency to decrease because of a lower herd size, but also a tendency to increase because of the need of more feed input and/or input of more expensive feed. In those cases mentioned farm return will be approximately the same while farm input will slightly increase, yielding a lower farm income. Changes in milk yield do not change our results in a significant way.

Also a change in investment costs does not change our results significantly. A ten percent lower investment cost results in a 1-2 percentage point increase of income. The exception is Germany with a 5 percentage point increase.

Assuming a labour reduction of 33% does change our results significantly. Income and cash flow per unit of family labour are now considerably higher for AM compared to a traditional parlour. The exception is Denmark, where cash flow is 12% higher, but income is still 6.29% lower. If labour reduction is only 7%, the AM-system becomes unprofitable in all countries.

Net present value for a seven-year period is higher for the AM-system, when a 33% labour saving is assumed for all typical farms except the Danish.

Table 24: Sensitivity analysis, percentage difference between the AM-system and the traditional parlour (the latter as reference)

	B	D	NL	DK
Income per hour of family labour, five years after investment				
Base simulation	+15.36	-14.26	+5.19	-37.04
Sensitivity to yield				
+12%	+13.86	-17.94	+7.65	-38.01
+18%	+10.96	-13.18	+8.66	-40.70
+24%	+11.50	-4.57	+10.15	-37.03
Sensitivity to investments				
Base -10%	+17.10	-9.78	+7.31	-29.25
Base +10%	+13.62	-20.09	+2.87	-47.90
Sensitivity to labour				
-7%	-2.03	-26.91	-10.70	-80.38
-33%	+36.00	+1.97	+24.03	-6.29
Cash flow per hour of family labour, five years after investment				
Base simulation	+22.40	+7.14	+18.16	+0.57
Sensitivity to yield				
+12%	+21.25	+5.52	+20.48	-0.29
+18%	+19.05	+8.04	+21.17	-1.33
+24%	+19.45	+12.81	+22.21	+0.02
Sensitivity to investments				
Base -10%	+23.35	+8.39	+19.05	+2.90
Base +10%	+21.42	+5.93	+18.11	-1.88
Sensitivity to labour				
-7%	+3.98	-8.79	+0.73	-15.86
-33%	+44.36	+26.33	+39.83	+12.04
Net present value of profits for the first 7 years				
Base simulation	+17.52	-19.65	-41.38	-87.27
Sensitivity to yield				
+12%	+14.52	-28.50	-29.50	-84.46
+18%	+9.96	-18.30	-25.20	-84.32
+24%	-4.68	-1.92	-18.46	-78.38
Sensitivity to investments				
Base -10%	+22.21	-11.25	-28.79	-61.21
Base +10%	+12.83	-35.75	-54.56	-108.53
Sensitivity to labour				
-7%	-20.92	-80.15	-96.84	-171.29
-33%	+50.46	+32.72	+6.16	-28.53

3.5 Confrontation with real farm results

In this section, results from our simulation model are confronted with results obtained from real AM farms in Denmark and the Netherlands. All the farms in our sample were asked permission to use their bookkeeping records for economic analysis. In Denmark, all thirteen farmers agreed, while in the Netherlands, only 30 of the 57 farms gave permission. Because not all the farms in the sample are comparable with our typical farm with respect to herd size, farm strategy, financing, labour, etc., it is not usefull to compare absolute results. Therefore, we compared income per kg milk[7], from two years before adoption until two years after adoption. The real farms are on average smaller (78 cows in NL and 106 cows in DK) than the typical farms used in the simulation (120 cows in NL and 142 cows in DK).

In the Netherlands, average income per kg milk of the real farms decreases after adoption, while on the simulated farm income per kg milk increases from the first year after adoption onwards (figure 6). Note that the simulated Dutch farm is combining the adoption of an AM-system with an increase in herd size, explaining the large decrease in year 0. It is normal on this farm that income per kg milk is increasing again after year 0. When comparing year 1 with year -1, we see a decrease of income per kg milk for the simulated farm, as on the real farms, but the decrease is less pronounced than on real farms.

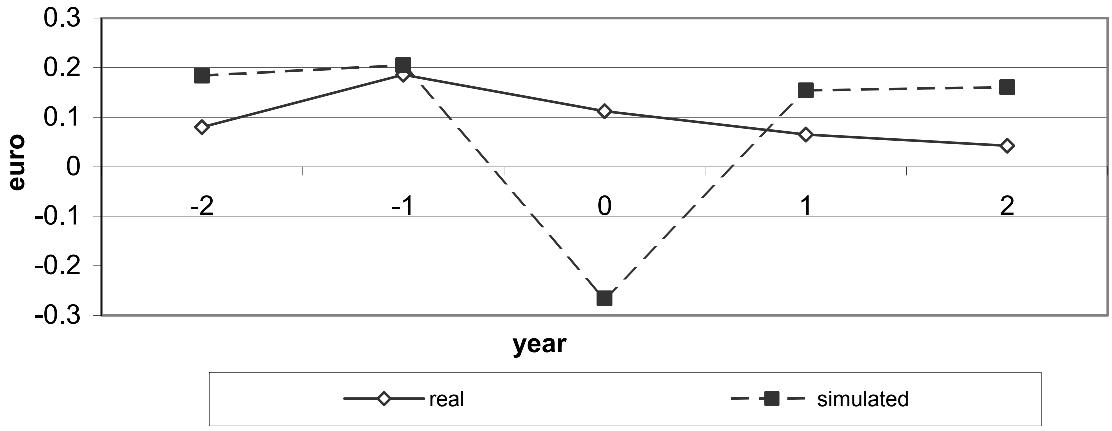

Figure 6: Evolution of income per kg milk on the simulated farm and an average of real farm results, the Netherlands

In Denmark, results of the real farms initially show the same pattern as in the Netherlands: a decrease of income per kg milk in the year of adoption, a further decrease the next year, but contrary to the Dutch farms, income increases two years after adoption (figure 7). The decrease in income in the simulated farm is much smaller and the recovery already occurs one year after adoption.

[7] To compare income per unit of family labour, we needed labour input for five consecutive years. This information was not available from the accounts. From the survey, we only know labour use before and after adoption.

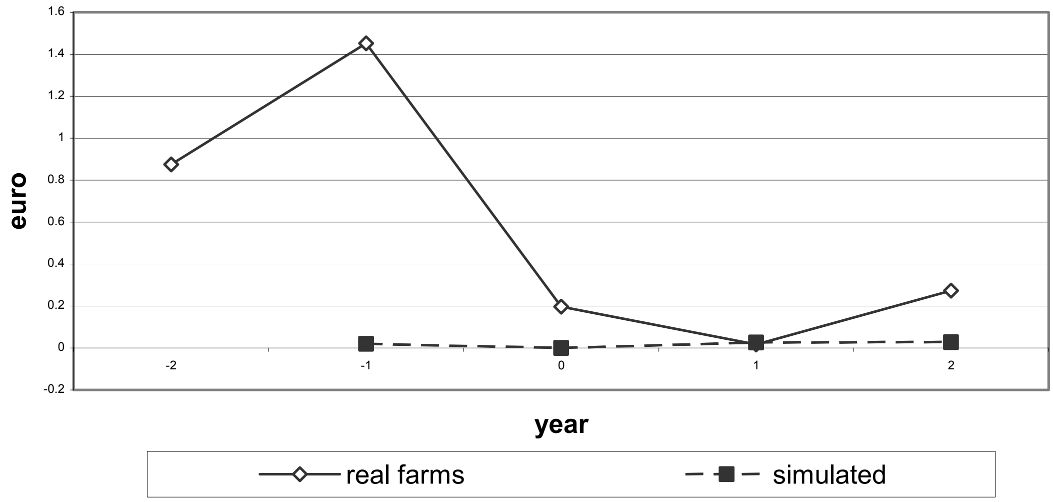

Figure 7: Evolution of income per kg milk on the simulated farm and an average of real farm results, Denmark

This confrontation of simulated results, which reflect an optimal situation, with real world results shows that in reality income decreases are much larger than often assumed. The speed of income recovery differs: Danish farms seem to recover faster than Dutch farms, but even the Danish farms only tend to recover only in the second year after investment.

4 Conclusions

Central to assessing the socio-economic implications of automatic milking on dairy farms is the reduction of labour needed for milking the cows and the increased flexibility of labour input. AM farmers report an average reduction of labour use of 20%. When hired labour is employed, it is laid off. When there is no hired labour, AM farmers use the free time primarily for non-productive purposes, that is, to spend more time on leisure and with the family. As a result, most AM users report that the quality of life of their family has increased. We have not found widespread evidence of any negative implications, such as increased stress.

The question is then whether these social benefits are offset by economic costs. A non-random sample of accounts shows that up to two years after investing in an AM-system, calculated income is considerably lower. However, results from accounts are difficult to interpret, as they often do not reflect the actual cash situation on farms, because they are used to minimize taxes. Therefore, we used simulation analysis on a set of typical farms to estimate the financial impact of AM.

For the typical farms in Belgium and the Netherlands investing in an AM-system is profitable if income per hour of family labour is used as an index of profitability. Income from the dairy enterprise always decreases, while profit from the dairy enterprise increases for the Belgian farm only. In other words, if farmers do not use the labour saved for other profitable activities, their income will go down. For the German typical farm, investing in an AM-system is not profitable, but it must be noted that also investing in a traditional parlour would be unprofitable given the initial situation of that typical farm (small herd size and low cash flow). However, this does not mean that automatic milking is not profitable in Germany in general. For larger farms that perform better, it is likely that results will be comparable to the other countries. This paper has simulated the investment in AM for typical farms and it is impossible to simulate all types of farms. Obviously, the results will be different for each individual farm as they depend on a variety of factors and each farmer should do his own calculus.

We conclude that farmers who have invested in an AM-system have in fact sacrificed some of their income, but of course the social benefits cannot be estimated in monetary terms. Nevertheless, we believe that income does not need to decrease, provided that some of the labour reduction is devoted to better farm management. Therefore, our main recommendation is that farmers investing in an AM-system should be adviced to use some of the free time to improve their farm management, such that they can reap both social and economic benefits from automatic milking.

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