EFFECTS OF AUTOMATIC MILKING AND CONVENTIONAL MILKING ON THE PROFITABILITY OF DUTCH DAIRY FARMS

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Abstract

The objective of this study was to analyze the profitability of dairy farms using an automatic milking system (AMS) compared with a conventional milking system (CMS) based on real accounting data. In total, 62 farms (31 AMS and 31 CMS) were analyzed for the year 2003, using a case control study. Results of 2003 showed that AMS farms used on average 29% less labor and had € 7,899 lower revenues. CMS farms had € 15,566 more available for rent, depreciation, interest, labour and profit (RDILP) than AMS farms. AMS farms had greater revenues, margin, and gross margin per full time employee, resulting in a substantial (but not statistical significant) greater RDILP per full time employee. Costs for depreciation and interest were larger for AMS farms than for CMS farms. Therefore, farm managers should consider the extra time acquired by automatic milking against extra costs associated with an AMS.

Key words: automatic milking, labour productivity, economics, profitability

Introduction

The first automatic milking systems (**AMS**) in the Netherlands were installed in 1992. The primary goal was to replace labor. In 2004, worldwide more than 2,200 farms were using an AMS (de Koning and Rodenburg, 2004). A survey in 2006 reported a total number of 4000, an increase of 25% with reference to 2005 (De Koning, 2006). Economic benefits of automatic milking are mainly savings in labor and increased of production per cow (Wade et al., 2004).

Reported labor savings by using an AMS differed from 18 % (Mathijs, 2004) to 38% (Sonck, 1995). Wirtz et al. (2004) reported that the milk production could increase up to 20%, whereas Wade et al. (2004) only found an average increase of 2% after the introduction of an AMS.

Several studies have been published on economic consequences of automatic milking (Arendzen and van Scheppingen, 2000; Hyde and Engel, 2002; Rotz et al., 2003). With some exceptions, the general trend in these studies was that automatic milking has negative effects on the economic performance of the farm when compared with conventional milking.

Economic studies conducted to date were based on normative models, where the advantages of automatic milking (labor savings and increased production) were compared with increased costs (depreciation, maintenance, and interest). A study on the economic aspects of automatic milking based on actual farm data is still lacking.

Therefore, the objective of this study was to analyze the profitability of the dairy farms with an AMS in comparison with farms using a CMS based on actual farm data.

Materials and Methods

Data

Data for this study originated from a Dutch accounting agency (Alfa accountants en Advisors, Wageningen, The Netherlands), one of the largest agricultural bookkeeping agencies in the Netherlands with customers throughout the whole country.

A database of 1,400 dairy farms was available for this research. Because not all data for 2004 were yet available, 2003 was used as the year of comparison. From this database, 31 farms with an AMS were selected.

A case control method was used in this study. Each farm with an AMS was matched to a farm that invested in a new CMS during the same year, selected from the same database. Matching was based on year of investment, the total milk production per year (maximum difference of 10%), and intensity of land use (defined as milk production per ha with a maximum difference of 1,000 kg/ha**).** This resulted in a total of 31 farms with an AMS (referred to as AMS31) and 31 farms with a CMS (referred to as CMS31) used in the study. On these 31 farms, 55 milking units were in use, an average of 1.77 milking units per farm.

Technical, financial and farm structure data of the 62 farms (AMS31 and CMS31) were available for the year 2003. In total, 244 variables were analyzed in this study. The most important variables are presented in this article.

The economic results of the two groups in absolute amounts were shown to give an indication about the total profitability. Besides these absolute economic figures, the economic results were also expressed per 100 kg of energy-corrected milk (**ECM**) to reflect the performance relative to the farm size. The ECM is used, because in the Netherlands the milk price is based on kilograms of fat and protein. The ECM is calculated as follows (Hemmer et al., 2004):

$$ECM = (0.337 + (0.116 \times \%F) + (0.06 \times \%P)) \times M,$$

Where M = true milk yield in kg; %F = fat percentage; and %P = protein percentage.

The farms were financially compared based on the amount of money that was available for rent, depreciation, interest, labor and profit (RDILP). The RDILP was calculated as gross margin minus the total non-accountable costs (excluding labor). Rent, depreciation, interest and labor are regarded as fixed costs, and therefore, are excluded when judging the performance of the farm. Larger purchase costs and shorter depreciation time of the AMS would have negative impact on financial outcomes of AMS farms. Therefore, the RDILP should be a good indicator of the dairy farm performance. Depreciation and interest costs, however, differ between milking systems and are important for economic performance. Available bookkeeping data were meant for fiscal use. Resulting estimates for depreciation and interest could therefore not be used for a business economic purpose. Therefore, per farm, depreciation and interest for milking equipment were calculated normatively (based on assumptions). For an AMS farm, number of milking units of that farm was multiplied with the purchase costs of 1 AMS unit. Purchase costs of 1 AMS unit (including building costs) were assumed to be €100,000. For a CMS farm, the investment in a milking parlor, including building costs, were estimated using the following function:

$Y_i = 65{,}500 * \log_e (X_i) -225{,}000$
where, Y_i denotes the total costs (including building costs) of a milking parlor for farm i and X_i denotes the herd size of farm i, with $40 < X_i < 200$.

The used, logarithmical, function gives credit to the decreasing marginal costs (€ per milking cow) of a milking parlor for increasing herd sizes. For an AMS and a CMS, a salvage value of 10 and 5%, respectively, of the purchase value were assumed. Economic life time was assumed to be 10 and 15 yr, respectively, for an AMS and a CMS. An interest rate of 5 % was used.

Data Analysis

A descriptive analysis was carried out by using SPSS 13.0 for Windows (SPSS, 2005). For all variables, the standard deviation of the mean was larger than 50%, from which was concluded that none of the variables were normally distributed. To test the null-hypothesis of no difference between AMS and CMS farms, a non-parametric test of 2 related samples, the 2-tailed Wilcoxon test, was used (Field, 2000). AMS31 and CMS31 were analyzed for the year 2003.

Results And Discussion

Study Design

Year of investment in a milking system for a CMS farm was similar to that of the comparable AMS farm. Total milk quota and land use did not differ between AMS and CMS farms (table 1). Average milk quota of the farms, however, was larger (almost 400,000 kg of milk) than the average milk production (442,904 kg of milk per farm) in The Netherlands (CBS, 2003). These data indicate that farms investing in an AMS are not average farms.

Table 1. Average structure of 31 farms using an automatic milking system (AMS31) and 31 farms using a conventional milking system (CMS31) in 2003

Item	AMS31	CMS31	*P*
Total land use, ha	60.0	61.7	0.906
Pasture, ha	44.29	48.96	0.170
Milk quota, kg	828,761	853,620	0.196
No. of dairy cows	105	110	0.681
Total labor FTE[1]	1.45	1.87	0.001
Entrepreneurial labor FTE	1.07	1.62	0.001
Family member labor FTE	0.19	0.07	0.024
Employee labor FTE	0.19	0.18	0.737
Dairy cows/family FTE[2]	85	65	0.001
Milk/family FTE, kg	674,642	508,017	0.001
ECM[3]/family FTE, kg	703,702	534,681	0.001
Dairy cows/total FTE	74	59	0.001
Milk/total FTE, kg	586,241	459,117	0.001
ECM/total FTE, kg	611,493	483,215	0.001
Milk/cow, kg	8,011	7,894	0.845
ECM/cow, kg	8,361	8,298	0.938

[1]FTE=Full time employee = 2540 h of work.
[2]Family FTE is the sum of entrepreneurial and family member FTE.
[3]ECM = Fat- and protein-corrected milk.

We examined performance of the farms after investment. Because the data of the accounting agency were only available for the most recent years a "before and after" analysis was not possible. By using a case control design, differences between farms were made as small as possible. Therefore, farms were comparable and results would be useful. Selection of data was done very strictly. It was, however, more important to have correct matching data instead of a larger number of farms.

Structure of Farms

Table 1 shows the structure of the farms used in the study. Total amount of labor, expressed as full time employee (**FTE**) equivalents, was smaller ($P < 0.001$) on AMS31 than on CMS31. Gustafsson (2004) found a 19% saving of labor when using an AMS. In our study, AMS31 used on average 29% labor less ($P < 0.001$) labor than CMS31. Labor costs for external workers were expected to be smaller for AMS31 because less labor should be needed. In our study, however, use of external workers was almost equal between the groups. This was also shown by the costs for external workers: AMS31 was €7,982 and CMS31 was €8,438. On average, 1,067 more ($P < 0.001$) hours of labor (approximately 20 h/wk) were required on CMS31 than on AMS31. A hard working family on a farm can compensate for this by working longer hours each day.

The range of the entrepreneurial FTE for AMS31 (0.5 to 1.6) indicates that the majority of AMS farms were run by a single family, whereas the range for CMS31 (1.0 to 2.5) indicates that some of the CMS31 farms were run by more than 1 family. This means that farm income must be divided. Because this information was not available, this can only be assumed.

As a consequence of the less labor use, efficiency of AMS31 was better. On farms with an AMS more ($P < 0.001$) cows were held and more ($P < 0.001$) milk was produced by a single FTE, both for total FTE and for family FTE. Although more cows per FTE were held on the AMS farms than on the CMS farms, average milk production per robot was 494,442 kg of milk. The capacity of 1 robot lies approximately between 600,000 and 750,000 kg of milk/yr (De Koning and Ouweltjes, 2000). Dairy farms in our study, however, were on average not utilizing the full capacity of the milking units. This indicates that there is space to grow within the existing capacity of the AMS.

Economic Results

Descriptive Overview

Table 2 shows the averages and the 5 and 95 percentiles of revenues, costs, margins, non-accountable costs, and RDILP. Calculation methods also are shown in this table. Differences between the systems are discussed later.

Table 2. Average, 5, and 95 percentiles of revenues, costs, margins, non-accountable costs and RDILP[1] (all in Euros) for 31 farms having an automatic milking system (AMS31) and 31 farms using a conventional milking system (CMS31) in 2003

	AMS31			CMS31		
	Average	5%	95%	Average	5%	95%
Revenues						
Milk	274,556	145,863	445,676	287,333	149,436	422,934
Payment milk quota surplus	-1,013	-6,011	0	-808	-2,372	43
Milk quality penalties	-45	0	0	-52	-24	61
Livestock	18,243	5,548	29,865	17,629	-3,131	36,966
Miscellaneous	7,506	133	21,531	3,046	0	14,782
Total (a)	299,248	170,300	455,178	307,147	172,287	456,512
Feed costs						
Concentrates	40,718	20,316	68,686	44,057	22,152	71,548
Substitutes for concentrates	5,519	0	10,631	6,734	0	21,045
Roughage	3,414	-3,863	11,223	3,081	-10,099	14,570
Milk products	1,651	0	3,600	1,838	0	6,569
Other feed	2,901	201	7,220	1,410	114	4,185
Total (b)	54,202	27,067	87,178	57,120	28,803	102,021
Livestock costs						
Health	4,526	1,311	10,937	5,135	1,548	11,245
Medicines	3,036	0	7,932	3,078	0	8,542
AI and breeding	5,136	561	12,034	7,871	3,318	20,415
Miscellaneous	5,508	1,460	12,480	4,474	953	7,921
Total (c)	18,205	6,460	32,230	20,559	8,742	36,804
Costs of land use						
Fertilizer	7,443	2,462	13,711	7,048	3,130	12,410
Seed	1,991	0	6,595	3,699	336	9,465
Pesticide	1,169	0	4,779	1,810	0	4,776
Miscellaneous	794	0	1,768	391	0	1,040
Total (d)	11,396	4,497	24,969	12,948	4,476	27,379
Total costs (b + c + d) (e)	83,804	40,249	131,645	90,626	47,982	152,808
Margins						
Margin on dairy (a – e)	215,444	118,937	337,370	216,521	124,513	321,746
Margin other farm activities	3,286	0	14,638	2,651	-1,200	14,866
Other activities	12,813	0	41,302	13,347	779	37,173
Gross margin (f)	231,542	123,731	364,341	232,519	127,639	336,610
Non-accountable costs						
Contractor	21,783	5,653	44862	15,361	3,369	28,597
Maintenance/insurance of:						
- machinery and equipment	28,088	10,705	52,718	24,411	8,172	48,126
- land, buildings, installations	7,404	1,329	15,546	5,371	-748	14,594
Gas, water and electricity	10,337	4,482	17,052	8,788	4,853	13,449
Other non-accountable costs	12,002	6,395	17,883	11,093	6,561	16,044
Total (g)	79,614	42,934	125,890	65,025	29,829	102,327
Available for RDILP (f – g)	151,928	80,073	262,962	167,494	82,627	249,811

[1]Rent, depreciation, interest, labor, and profit.

Dairy Production

Table 3 shows milk production of AMS and CMS farms. Protein percentage was greater ($P < 0.02$) for farms using a CMS. The ECM tended ($P = 0.065$) to be larger for the farms using a CMS. In Table 4, revenues, costs, and margins are given for the whole farm and expressed per 100 kg of ECM. In The Netherlands, production capacity is made up by the milk quota. Milk payments are based upon the delivered amount of fat and protein. Economic performance per 100 kg of ECM is therefore important.

Table 3. Average milk production, fat percentage, protein percentage and energy-corrected milk (ECM) of 31 farms having an automatic milking system (AMS) and 31 farms using a conventional milking system (CMS) in 2003

	AMS31	CMS31	*P*
Milk production, kg/farm	836,095	847,057	0.203
Fat, %	4.33	4.37	0.264
Protein, %	3.42	3.47	0.017
ECM, kg/farm	870,585	891,057	0.065

A difference was shown in milk revenues (Table 4), both absolute ($P = 0.003$) and per 100 kg of ECM ($P = 0.002$), between AMS and CMS farms. Milk price was the same for the 2 farm types, but because of larger protein and fat percentages, corrected milk price was larger ($P = 0.002$) for CMS31. This difference, however, was not expressed in the total revenues, because of numerically larger miscellaneous revenues of AMS31. No difference was detected in costs. The margin on dairy production per 100 kg of ECM was nearly identical.

Table 4. Average revenues, costs and margin on dairy in Euros, absolute and per 100 kg of energy-corrected milk (ECM) of 31 farms having an automatic milking system (AMS) and 31 farms using a conventional milking system (CMS) in 2003

	Absolute			100 kg of ECM		
	AMS31	CMS31	*P*	AMS31	CMS31	*P*
Milk revenues	274,556	287,333	0.003	31.53	32.27	0.002
Miscellaneous revenues	24,692	19,815	0.583	2.82	2.27	0.232
Total revenues	299,248	307,147	0.112	34.35	34.54	0.544
Concentrate costs	40,718	44,057	0.357	4.67	4.83	0.481
Total feed costs	54,202	57,120	0.290	6.47	6.33	0.845
Health costs	7,561	8,213	0.597	0.84	0.93	0.681
Total livestock costs	18,205	20,559	0.468	2.01	2.25	0.531
Land use costs	11,396	12,948	0.224	1.28	1.46	0.170
Total costs	83,804	90,626	0.164	9.76	10.04	0.505
Margin dairy production	215,444	216,521	0.597	24.60	24.50	0.953

Profitability

Costs for contractors and costs for gas, water, and electricity were greater ($P < 0.05$) for farms with an AMS than for those using a CMS (Table 5). Larger contractor costs of an AMS farm might be explained by a different feeding strategy on these farms. The 29% lesser requirement of labor on AMS farms (Table 1) might not necessarily only be caused by a reduced amount of labor for milking, but also could be caused by increased use of contractors. The net result (profit) of a farm is used many times in comparisons. Considering that the net result is dependent on the financial structure of a specific farm, comparing on this basis might, therefore, actually be merely a comparison of farm structure and not of farm management. The RDILP is, therefore, a good measure to estimate the overall profitability independent of farm structure. The RDILP represents the benefits and those cost factors that are not necessarily expenses. The RDILP was larger (*P* < 0.05) by €15,566 for CMS31 farms, caused by the smaller non-accountable costs of CMS31. The same results were found per 100 kg of ECM.

Table 5. Average gross margin, non-accountable costs and available for RDILP[1] in Euros, absolute and per 100 kg of energy-corrected milk (ECM) of 31farms with an automatic milking system (AMS) and 31 farms with a conventional milking system (CMS) in 2003

	Absolute			100 kg of ECM		
	AMS31	CMS31	*P*	AMS31	CMS31	*P*
Margin dairy production	215,444	216,521	0.597	24.60	24.50	0.953
Gross margin	231,542	232,519	0.754	26.51	26.34	0.938
Contractor	21,783	15,361	0.004	2.55	1.81	0.003
Gas, water, electricity	10,337	8,788	0.021	1.24	1.01	0.007
Maintenance/insurance of:						
- machinery and equipment	28,088	24,411	0.136	3.15	2.72	0.078
- land, buildings, installations	7,404	5,371	0.104	0.88	0.60	0.122
Total non-accountable costs	79,614	65,025	0.002	9.29	7.46	0.001
Available for RDILP	151,928	167,494	0.046	17.22	18.87	0.046

[1]Rent, depreciation, interest, labor, and profit.

Expressed per FTE (Table 6), AMS farms had greater (*P* < 0.05) revenues, margin, and gross margin per FTE than CMS farms. The AMS farms also had a numerically greater RDILP per FTE (€12,953). Because there was no difference in the use of external labor, this means that the farmers using an AMS do not save money by reducing external work, but increase their opportunity costs by reducing their own labor. This is a clear advantage of automatic milking that might differ from farm to farm, depending on opportunity costs of labor on a specific farm, which might vary from 0 to €21,840 (1,092 h at €20/h).

Table 6. Average revenues, costs, margin on dairy production, gross margin, and money available for RDILP[1], expressed for full time equivalent for labor (1 FTE = 2,540 h) for the difference between automatic milking system (AMS) and conventional milking systems (CMS) for the year 2003

	Milking system	
Item	AMS31	CMS31
Total revenues	206,378	164,250[a]
Total costs	57,796	48,463
Margin on dairy production	148,582	115,787[a]
Gross margin	163,056	127,939[a]
Available for RDILP	101,372	88,429

[a] Different (*P* < 0.05) from AMS.
[1] Rent, depreciation, interest, labor, and profit.

Results shown so far, do not account for depreciation and interest. For several reasons, the exact depreciation of AMS and CMS are not known. Because depreciation and interest are important factors in the financial results of a farm business, we chose a normative in estimating these costs. Average purchase value of the AMS (including costs for the building) was estimated to be €177,419, with a yearly depreciation of €15,968, and a calculated average yearly interest of €4,879. This resulted in average total equipment costs for an AMS, excluding maintenance, which was part of the data described above, of €20,847. Average purchase value (including costs for the building) of a CMS was estimated to be €78,210. Estimated yearly depreciation and average yearly interest were estimated to be €4,953 and €2,053 respectively. Average total yearly costs for a CMS were €7,006. This was €13,841 less than the estimated yearly costs for an AMS. Although most economic studies (Cooper and Parsons, 1999; Arendzen and van Scheppingen, 2000; Hyde and Engel, 2002) use a shorter economic life time for an AMS, no reliable estimates exist on the economic life span of an AMS in comparison to a CMS. The, assumed, shorter life time, however, may in practice be compensated with a greater replacement rate of components of the AMS. In our study, we also found numerically greater maintenance costs for the AMS. Economic life span of the AMS is important because of its profitability relative to a CMS. If the economic life span of an AMS equaled that of a CMS, difference in costs for depreciation and interest between the 2 systems would be €8,518 instead of €13,841. For future comparisons, it would be good to gain more insight into the real economic life span of AMS and CMS.

Given the present results, it is clear that profitability in terms of money available for RDILP is smaller in farms using an AMS. Moreover, farms with an AMS have larger depreciation and interest costs compared with the farms using a CMS. As calculated above, on average, the maximum opportunity costs is €21,840 (1,092 h at a rate of € 20/h). On average, this amount is not enough to cover the increased costs for depreciation (€13,841) and lesser amount of money available for RDILP (€15,566). This indicates that for many dairy farmers, adoption of an AMS system is more than just a pure economic decision, but a socio-economic decision (Hogeveen et al., 2004; Mathijs, 2004).

Conclusions

Farms with an AMS used on average 29% less (own) labor than farms using a CMS. Farms using a CMS had larger revenues (€7,899), but farms with an AMS had smaller costs, especially livestock (€2,354) and feeding costs (€2,918). No differences in margin on dairy were detected between the 2 milking systems. Fixed costs (excluding labor, depreciation, and interest) were larger for AMS than for CMS farms (€ 4,589). Larger fixed costs were caused by larger contractor costs (€6,422) and costs for gas, water, and electricity (€1,549). Because of these larger costs the farms using a CMS had more money available for RDILP.

When expressed per FTE, AMS farms had greater revenues, margin, and gross margin per FTE than CMS farms. The AMS farms did have a numerically greater RDILP per FTE (€12,953) than that for CMS farms. Although depreciation and interest were not available in our study, normative calculations showed larger depreciation and interest costs for AMS. When deciding between investment in an AMS or a CMS, dairy farmers must weigh decreased labor needs for the AMS against increased fixed costs of milking with an AMS.

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