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Profitability of Swiss Dairy Farms with Different Milking Systems

Wirtschaftlichkeit Schweizer Milchviehbetriebe mit verschiedenen Melksystemen

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Summary

The choice of an investment in a milking system has a long-term influence on the labour organisation and cost structure of dairy farms. Based on Swiss farm-level accountancy and survey data for 2020, the structure and economic performance of 455 farms grouped by different milking systems and regions are analysed. The results show that farms with bucket or pipeline milking systems are smaller than farms with milking parlours and automatic milking systems. The physical labour input per animal is lower with modern milking systems. Farmers' investments in automatic milking systems are a more recent development, occurring more frequently on farms with larger herds. Additionally, the more recent the milking system, the lower the profitability. The milking system has no influence on profitability.

Keywords: dairy farms, milking system, profitability

Zusammenfassung

Die Entscheidung für eine Investition in ein Melksystem hat einen langfristigen Einfluss auf die Arbeitsorganisation und die Kostenstruktur von Milchviehbetrieben. Auf der Grundlage von Schweizer Buchhaltungs- und Erhebungsdaten für das Jahr 2020 werden die Struktur und die Wirtschaftlichkeit von 455 Betrieben analysiert, die nach Melksystemen und Regionen gruppiert werden. Die Ergebnisse zeigen, dass Betriebe mit Eimer- oder Rohrmelkanlagen kleiner sind als Betriebe mit Melkständen und automatischen Melksystemen. Der Arbeitsbedarf je Tier ist bei modernen Melksystemen tiefer. Die Investitionen der Landwirte in automatische Melksysteme sind jünger und kommen häufiger in Betrieben mit größeren Tierbeständen vor. Außerdem ist die Wirtschaftlichkeit umso geringer, je neuer das Melksystem ist. Das Melksystem hat keinen Einfluss auf die Wirtschaftlichkeit.

Schlagworte: Milchviehbetriebe, Melksystem, Wirtschaftlichkeit

1 Introduction

Despite an above-average decline in the number of dairy farms compared to other farm-types since the early 2000s, dairy farming in Switzerland still accounts for around 40% of all farms, indicating the industry's significant impact on grassland use and the production of agricultural commodities for food (Zorn, 2020; Agristat, 2021). However, the income of dairy farms remains below average compared to other farm types (Hoop et al., 2021). In addition, input and output prices in the dairy sector have become more volatile over time (El Benni and Finger, 2013; Agristat, 2021; Frick and Sauer, 2021; Kozak et al., 2022). To remain or become more competitive by reducing costs, farmers need to adapt, including investing in new equipment. Milking systems, which are more expensive but require less labour inputs, are a very important long-term investment decision for dairy farmers (Gallardo and Sauer et al., 2018). Therefore, each investment must be carefully considered based on farm-specific investment calculations. To determine the dairy farm's competitive performance, as defined by Thorne et al. (2017), the question is: Does the milking system affect the profitability of dairy farms?

In recent years, studies on the profitability of different milking systems have focused on the differences between automatic and conventional milking systems. Most of these studies have been based on model calculations or simulations. However, there are differences in the results between studies. On the one hand, Shortall et al. (2016) concluded in a study from Ireland that their model farms with automatic milking systems (AMS) were less profitable than the model farms with conventional milking systems. On the other hand, Salfer et al. (2017) found that model farms with 120 and 240 cows were more profitable with an AMSs than with a parlour milking system (PMS). However, the model farm with more than 1000 cows with an AMS was less profitable.

Empirical studies have aimed to answer questions of efficiency (Steeneveld et al., 2012; Heikkilä and Myyrä, 2014; Hansen et al., 2019a) or to investigate profitability and compare matched farms using regressions (Bijl et al., 2007; Hansen et al., 2019b; Gargiulo et al., 2020). Again, the results are heterogeneous. While Steeneveld et al. (2012) concluded that there are no differences between milking systems in terms of technical efficiency and dependence on investment time, Hansen et al. (2019a) showed that higher revenue efficiency between farms could be explained by the presence of an automatic milking system, among other factors. Bijl et al. (2007) concluded that farms with AMS perform better than farms with conventional milking systems in terms of performance indicators per labour input. Hansen et al. (2019b) showed that AMSs are only more profitable than other milking systems above a certain herd size, with profitability increasing with the age of the investment. However, Gargiulo et al. (2022) found no significant differences in profitability between AMSs and others for grassland-feeding farms. Finally, the meta-study by Örs and Oguz (2018) showed that in 5 of 7 studies, net income was lower for dairy farms using AMSs than for those using conventional milking systems. In Switzerland today, the majority of farms still use either bucket or pipeline milking systems (BPMS) or PMS. Only a small proportion of farms have so far decided to invest in automatic milking systems (Groher et al., 2020). The only study on the profitability of newer milking systems in Switzerland is that by Gazzarin and Nydegger (2014), who used a calibrated model to calculate profitability.

The main objective of this study is to empirically determine whether the choice of milking system in Switzerland has an influence on the profitability of farms. This broad question can be roughly divided into three sub-questions:

1. Does the milking system affect the family farm income (FFI) per family work?
2. Does the milking system influence the different components of the FFI, namely the outputs and inputs?
3. Do farms have different structures or other characteristics with regard to their milking systems?

The contributions of the present study complement existing studies in the following ways. It empirically analyses the profitability of farms with different milking systems. This is the largest study to date on the profitability linked to automatic milking systems in Switzerland, and it provides information on the structure of existing Swiss farms with regard to different milking systems. The paper is structured as follows. Section 2 deals with the data and the methods used. Sections 3 and 4 present the descriptive and empirical results, respectively. Section 5 contains a discussion, and section 6 concludes the paper.

2 Data and Method

There are two farm accountancy datasets in Switzerland (Renner et al., 2019). The one used in the analysis of this study collects data on farm management. It contains annual data on 1600 farms with different farm types from three regions. The data comprise detailed monetary figures and structural information, such as information on labour, land, animals or farming systems, but no details on machinery, equipment or buildings. To collect data on the milking system, a survey was sent to all specialised dairy farms participating in the 2021 Farm Management Sample for the accounting period of 2020. Eighty percent of recipients responded to the survey, and after a consistency check on the milking system, milking units and stable, data from 455 farms were used for the analysis. This included 214 farms with a BPMS, 217 farms with a PMS, and 24 farms with an AMS.

This study estimates the effects of the choice of milking system using a multivariate ordinary least squares (OLS) model, which allows to control for other observed farm characteristics, such as size. This is the only feasible model, given the small number of observations, and it allows for the easy interpretation of the results. This paper focuses on four different dependent variables, each one for a given economic indicator of profitability: 1) the FFI, 2) the FFI increased by the depreciation of fixed equipment[1] to compensate for the different depreciation states of milking systems, 3) the outputs per dairy cow and 4) the expenses per dairy cow. The FFI is the annual surplus generated by the farm, which is available as remuneration for the farm work by unpaid family labour and for the equity invested in the farm. As there is no interest on the capital at this stage, the farm income is equal to the labour income.

The main independent variables are defined as 1 if AMS or PMS and 0 if otherwise. As control variables, I include the number of dairy cows for farm size, which is also quadratic in the model, as well as the regions' natural production conditions, the organic farming system and the type of production without silage, which are taken into account via dummies and the year in which the milking system was purchased.

3 Descriptive Results

Table 1 presents the characteristics of the different milking system groups in terms of farm structure and profitability for each typical region[2] in Switzerland. For the hill and mountain regions, only the differences between farms with a BPMS or PMS were examined because there were too few farms for the analysis of the AMS. Differences in farm characteristics between these three groups were examined using non-parametric Wilcoxon rank-sum or chi-squared tests.

There are no differences in organic farming and milking systems, except in the hill region, where significantly more organic farms have a PMS. With regard to the unpaid (family) labour input and the age of the farm managers, the farm groups corresponding to the different milking systems do not differ. There are significant differences between groups according to farm size, both in terms of agricultural area and livestock. Farms with a BPMS are the smallest farms, followed by farms with a PMS. Farms with an AMS are the largest. The share of external labour is higher on farms with a PMS than on farms with a BPMS in the hill and mountain regions. In the valley region, the stocking rate (animals per utilised agricultural area UAA) and the proportion of silage maize per UAA are higher on AMS and PMS farms than on BPMS farms. In the valley region, AMS farms manage the largest herds per labour input, with about 36 livestock units (LU) per annual work unit (AWU), followed by PMS farms with about 23 LU per AWU and BPMS farms with about 17 LU per AWU. In the valley region, the milk yield is higher on AMS farms with 8,800 kg/milk cow and year than on PMS farms with 7,900 kg/milk cow and year or 7,500 kg/milk cow and year on farms with a BPMS. In the other regions, there are no differences in milk yields based on the milking systems. The use of concentrate per kg milk produced is at the same level for each milking system in each region.

The main results for the monetary outputs and inputs per farm size unit (dairy cows or UAA) show no differences between the farm groups. However, in the valley region, the resulting key figures for agricultural income and labour earnings differ between farms with a BPMS and farms with the other two milking systems. In the mountain region, farms with a PMS achieve a higher agricultural income and labour income by CHF 10,000 than farms with a BPMS. The higher depreciation of investments is remarkable for the AMS farms in the valley region, where the date of investment in the milking system is more recent than for the other two groups. In all regions, the depreciation of fixed installations differs less between BPMS and PMS than between these and AMS. Trying to standardise the (monetary) state of the investments by considering these higher depreciations for fixed installations (around CHF 20,000 for AMS), the farms with an AMS achieve a significantly higher FFI. The same applies to PMS compared to BPMS, but the difference is less pronounced. However, if FFI is related to the milk produced, the AMS farms have a lower family farm income per kg of milk produced than the farms with a BPMS or PMS.

For the analysis of non-agricultural activities, only individual farms are used (i.e., this study did not consider farm associations), as the key figures for work and income from non-agricultural activities were not collected for farm associations. In the case of individual farms, we do not observe any significant differences between the groups in the proportion of working days for non-agricultural activities or in the absolute figures for non-agricultural income.

4 Results of the Regression Analysis

Four dependent variables are considered, and the main independent variable indicates which milking system the farm adopted. Table 2 shows the results of the regression analysis. Each column of the table represents one regression with a different dependent variable. In the first regression, the coefficient of the PMS is 2.327 and that of the AMS is - 2.524, and neither is significant. The coefficient of the year of investment in the milking system is -0.341 and significant. This means that a one-year-younger milking system compared to another would reduce the FFI by CHF 351 or 0.6% of the average FFI in 2020. The other control variables farm size and silage-free farming system are found to have a significant influence on FFI while the regions and the organic farming system are not. In the second regression with FFI increased by the depreciation of fixed equipment, the coefficient of the PMS is 3.574, and the coefficient of AMS is 8.243, but neither was significant. This means that switching to a PMS or AMS has no effect on the adapted FFI. The coefficient of the year of investment in the milking system is -0.260 but insignificant. As in the first model, the other control variables, farm size and silage-free farming system,

1 It is used as an approximation as there is no detailed information on the milking system within the fixed equipment.

2 The classification of the "regions" is based on the agricultural zones. The criteria for these are the climatic situation (vegetation period), the traffic situation, and the surface design or the proportion of sloping and steep slopes.

Table 1. Characteristics of the three milking system groups in terms of farm structure and profitability (average) in 2020 in the plain, hill and mountainous regions

Region	Plain			Hill		Mountain	
Milking system	**BPMS**	**PMS**	**AMS**	**BPMS**	**PMS**	**BPMS**	**PMS**
Farms (n)	44	86	15	86	85	84	46
Farm structure							
Organic farming (%)	14	7	0	9^{2*}	26^{1*}	25	37
Year of investment in the milking system	$1999^{2***,3***}$	$2004^{1***,3***}$	$2016^{1***,2***}$	2003	2006	2003^{2**}	2009^{1**}
Unpaid (family) labour (AWU)	1.6	1.53	1.66	1.41	1.54	1.55	1.55
Paid labour (AWU)	0.46^{2*}	0.75^{1*}	0.42	0.39^{2***}	0.66^{1***}	0.26^{2***}	0.53^{1***}
Age of farm manager	50	47	48	49	47	46	46
Utilised agricultural area (UAA) (ha)	$26.54^{2**,3***}$	30.23^{1**}	40.19^{1***}	20.36^{2***}	26.91^{1***}	24.13^{2**}	30.12^{1**}
Silage maize (ha)	2.16^{3***}	3.1^{3**}	$6.46^{1***,2**}$	0.33	0.71	0	0
Total livestock (LU)	$34.74^{2***,3***}$	$51.69^{1***,3***}$	$74.19^{1***,2***}$	30.82^{2***}	45.33^{1***}	25.65^{2***}	35.30^{1***}
Dairy cows (LU)	$26.81^{2***,3***}$	$43.00^{1***,3**}$	$61.59^{1***,2**}$	22.13^{2***}	31.90^{1***}	17.91^{2***}	24.04^{1***}
Animal stocking (LU/ ha)	$1.31^{2***,3**}$	1.71^{1***}	1.85^{1**}	1.51	1.68	1.06	1.17
Livestock per labour input (LU/AWU)	$16.86^{2***,3***}$	$22.73^{1***,3***}$	$35.55^{1***,2***}$	17.18^{2*}	20.62^{1*}	14.17^{2*}	17.02^{1*}
Milk yield (kg per cow and year)	$7'455^{3**}$	$7'899^{3**}$	$8'845^{1**,2**}$	6’797	7’008	6’486	6’757
Output/Input/Income							
Output: Total per dairy cow (CHF/LU)	11’572	10’774	10’360	11’957	11’691	12’234	13’363
Output: Livestock per dairy cow (CHF/LU)	6’746	6’909	6’944	6’768	7’049	$6'221^{2**}$	$7'141^{1**}$
Output: Direct payments per UAA (CHF/Ha)	$2'322^{2***,3**}$	$2'404^{1***}$	$2'211^{1**}$	2’932	3’183	3’289	3’505
Input: Total CHF per dairy cow	8’727	8’335	8’321	9’089	8’911	9’181	10’524
Input: Concentrate per milk yield (CHF/kg)	0.14	0.13	0.15	0.17	0.16	0.15	0.18
Depreciation: Fixed installations (CHF)	$3'576^{2*,3**}$	$8'404^{1*,3***}$	$33'509^{1**,2***}$	2’985	5’255	$2'134^{2***}$	$7'936^{1***}$
Variable input on total input (%)	39	41	45	41	45	49	49
Agricultural income (CHF)	$76'270^{2***,3**}$	$104'894^{1***}$	$125'611^{1**}$	$64'475^{2*}$	$88'694^{1**}$	$54'694^{2*}$	$68'235^{1*}$
Family farm income per family work (CHF/AWU)	$47'758^{2***,3**}$	$68'740^{1***}$	$75'572^{1**}$	45’139	57’639	$35'233^{2**}$	$44'081^{1**}$
Farms[4] (n)	204	203	19	85	78	81	44
Off farm income[4] (CHF)	19’461	21’210	11’323	30’199	28’280	25’619	25’100
Working days off farm per total working days[4] (%)	8	10	4	17	16	13	14

[1]Different from BPMS; [2]Different from PMS; [3]Different from AMS; Signif. levels: * < 0.1, ** < 0.05, *** < 0.01. [4]Only available for individual farms, since key figures on non-agricultural activities were not collected for farm associations. 1 Euro = 1.078 CHF (31 December 2020). Abbreviations: BPMS = bucket or pipeline milking system, PMS = parlour milking system, AMS = automatic milking system, AWU = annual work unit, UAA = utilised agricultural area, LU = livestock unit, CHF = Swiss francs.
Source: Own calculations, 2022.

Table 2. Results of the regression analysis on family farm income per family work, output per dairy cow and input per dairy cow

Variable				
Y	Family farm income per family work[1]	Family farm income per family work adapted depreciation[1,2]	Output total per dairy cow[1]	Input total per dairy cow[1]
Dairy cows (LU)	1.767*** (0.283)	1.731*** (0.305)	-0.135*** (0.042)	-0.095** (0.039)
Dairy cows ^2 (LU)	-0.010*** (0.003)	-0.008** (0.003)	0.008* (0.004)	0.005 (0.004)
Year of investment in the milking system	-0.341** (0.153)	-0.260 (0.165)	-0.024 (0.023)	-0.002 (0.021)
Milking system (PMS) (1,0)	2.327 (3.186)	3.574 (3.439)	1.018** (0.471)	0.905** (0.436)
Milking system (AMS) (1,0)	-2.524 (7.443)	8.243 (8.036)	1.402 (1.101)	1.308 (1.018)
Region (hill) (1,0)	-3.105 (3.414)	-4.686 (3.685)	-0.102 (0.505)	0.209 (0.467)
Region (mountain) (1,0)	-5.693 (4.041)	-6.956 (4.362)	0.458 (0.598)	0.406 (0.552)
Organic farming system (1,0)	3.192 (3.636)	5.230 (3.925)	0.593 (0.538)	0.052 (0.497)
Silage-free farming system (1,0)	8.103*** (2.900)	9.569*** (3.131)	-0.141 (0.429)	-0.371 (0.397)
Constant	694.094** (305.448)	532.891 (329.752)	63.036 (45.185)	14.841 (41.759)
R-squared adj.	0.27	0.30	0.06	0.03

Signif. * < 0.1, ** < 0.05, *** < 0.01. Standard errors are in brackets. [1] 1000 CHF; [2] Input was reduced for depreciation on fixed installations. Number of observations: 455 farms.
Source: Own calculations, 2022.

are found to have a significant influence on FFI, while the regions and organic farming system are not. In the third regression of the total output per dairy cow, the coefficient of PMS is 1.018 and significant, implying a higher output per dairy cow by CHF 1,018 if farms switch to PMS. The coefficient of AMS is 1.402 but insignificant. Except for the farm size variable, none of the control variables are significant. In the last regression model, the total input per dairy cow of PMS is 0.905 and significant. This means that the input per dairy cow would be higher by CHF 905 if farms switched to PMS. The coefficient of AMS is 1.308 but insignificant. As in the third regression model, only the control variable of farm size is significant.

5 Discussion

Our results on the profitability of different milking systems complement the few but heterogeneous results of previous empirical studies and closely reflect those of Gargiulo et al. (2022), who also found that milking systems have no influence on profitability. The similarity of the structures of the Norwegian farms analysed in Hansen et al. (2019b) and the Swiss farms in the present study would have led us to expect a similar result. However, the question of whether the higher proportion of AMS farms in Norway has an influence cannot be answered. It is precisely this smaller number of AMS farms and their farm structures, which are very different from the farms of the other milking systems, that limits the validity of the present comparison. To better understand the treatment effects in non-random studies, the individuals in the groups could be matched or weighted to minimise their structural differences. In this study, this was not possible because the farms with AMSs had too little overlap in the characteristics with the farms in the other groups.

From the descriptive results, it might be expected that the regression would show a correlation between the FFI and the milking systems. However, this is not the case and the farm size and the age of the milking systems appear to have a stronger effect through the ceteris paribus consideration. The comparison of the two models with and without taking into account the depreciation of the fixed installations illustrates the relationship with the year of investment. If depreciation is not taken into account, the age of the milking system no longer has any influence. This, in turn, means that individual milking systems that differ in age, on average, between the groups would not be systematically disadvantaged. This applies to all milking systems and not only to farms with AMSs with significantly higher investment costs. The fact that farms with younger milking systems achieve lower income levels may be supported by Kramer et al. (2019) who found a decrease in calculated profit for farms in the first years after investment in a dairy barn.

6 Conclusion

The present study is the first to empirically analyse the differences between Swiss farms in terms of structure and profitability according to the milking systems used. The BPMS and PMS are still the most common milking systems, with more farms in hill and mountain regions using the BPMS. The clear differences in the number of livestock per labour input highlighted the great gaps in physical labour requirements between these milking systems. Investment in a more modern milking system is frequently found to be associated with an increase in farm size. Bigger farms tend to have higher FFI at higher intensities and fewer off-farm activities. The AMS tends not to be used on smaller farms. On the one hand, an AMS enables farms to manage larger herds, on the other hand, the higher investment costs for these milking systems must be covered by higher returns - in this case with more animals - to ensure economic profitability. On the positive side, specialised dairy farms with an AMS in Switzerland are not worse off in terms of profitability than farms with other milking systems. In this study, only specialised dairy farms are considered. Future studies could also include mixed farms that may use their milking system in a different farm concept, such as direct marketing or similar. This could also increase the number of observations. The comparison groups could be better matched if there were enough farms in both groups. This could be the case in the future if either smaller AMS farms or larger BPMS and PMS farms become established and can thus be included in the sample.

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