DETERMINANTS OF FULL COSTS OF DAIRY PRODUCTION IN SWITZERLAND – A COMPARISON OF TWO DISPROPORTIONATE JOINT COSTS ALLOCATIONS

Daniel Hoop, Alexander Zorn, Markus Lips and Christian Gazzarin

Agroscope
Institute for Sustainability Sciences (ISS) – Farm Management Group
Tänikon 1, 8356 Ettenhausen, Switzerland

Abstract

By means of a maximum entropy joint cost allocation model with farm-specific allocation factors that account for economies of scale, full costs of 198 milk producers in the Swiss plain region are calculated. The effect of farm-specific allocation factors is found to be small; nevertheless it contributes to a more precise joint cost allocation to the enterprises of a farm. Average milk costs are CHF 1.31/kg – twice as high as producer milk price – and differ substantially between farms. In a regression analysis, the herd size and the milk yield per cow turned out to be the major cost-cutting factors.

Keywords: Full cost analysis; maximum entropy; disproportionate joint cost allocation; milk; Switzerland; FADN

1. Introduction

According to the dairy report of the International Farm Comparison Network (IFCN, Hemme et al., 2014) Swiss dairy farms (on average with 22 cows) show the highest production costs worldwide (174 $[1]per 100 kg milk). In Swiss agricultural politics it is often argued that the high production costs not only result from small structures but also from high environmental standards, animal-friendly husbandry and adverse topographical and climatic conditions. However, while the full costs of dairy production have been addressed in the literature (e.g., Haas and Höltschi, 2012; Lips, 2014a) to our knowledge there exists no analysis of the determinants of full costs. In order to improve farm efficiency and decrease production costs, it is important for farmers, consultants and policy makers to know not only the range of production costs but also their determinants.

The great challenge for full cost analysis in Swiss agriculture is the usually high degree of diversification of farms, meaning that each farm has several enterprises also called production branches or activities. As soon as a farm has more than one enterprise, joint cost items like labour, machinery, or buildings need to be allocated to the single enterprises (and their products). Beyond the so-called proportional joint cost allocation that is often applied in literature (e.g., Hemme et al., 2014) a disproportionate allocation by means of maximum entropy favours the adjustment of large joint cost allocation factors before small ones (Lips, 2014a).

Compared to Lips (2014a), in this paper a further developed maximum entropy joint cost allocation model including agricultural related activities (also called other gaining activities OGA) is used allowing to compare two types of allocation. While the first one uses the same allocation factors for all farms under consideration, the second is based on farm-specific allocation factors that account for economies of scale effects related to the size of an enterprise.

The aim of this paper is twofold. Based on the full costs per kilogram of milk of a large sample of farms, the determinants of costs are considered by means of regression technique.

[1] In the year of the analysis 2012 the exchange rate was 1 $ = 0.94 Swiss Francs (Hemme et al., 2014).

In addition, it is analysed whether and how allocation factors reflecting economies of scale are affecting the results. To our knowledge such an analysis based on actual costs (accountancy) for a broad group of dairy farms has not been carried out yet.

The paper is organized as follows: Section two describes the Farm Accountancy Data Network (FADN) data used. The third section describes the applied methodology to derive full costs at the enterprise level. Section four shows the results and the determinants of the full costs, while section five is devoted to the discussion and conclusions.

2. Data

For the analysis we focus on farms of the Swiss FADN which fulfil two conditions. First, they should have a focus on milk production. Second, the farms should have some diversification which enables us to analyse interactions between enterprises. We focus on combined dairy and arable farms located in the plain region of Switzerland from the year 2012. The 198 farms under consideration are managed according to the regulations prescribed for sustainable ecological agriculture[2] (but not according to organic standards) as it is the case for the majority of Swiss farms, possess 34.2 livestock units (LU) per farm and 31 LU within the dairy enterprise of which 26 are dairy cows (Table 1). The average utilized agricultural area (UAA) of 29 hectares (ha) is located 517 meters above sea level. With a milk yield of 7780 kg•(dairy cow)$^{-1}$•year^{-1} they produce 202’280 kg milk•year^{-1} of which 193’500 kg leave the enterprise (while the rest is fed within the enterprise). On average, the farms comprise 10.3 enterprises which illustrates the high degree of diversification.

The following cost categories were used for the calculations: (1) direct costs [in Swiss Francs, CHF], (2) work [in normal working days, NWD], (3) machinery costs [CHF], (4) building costs [CHF], and (5) other joint costs [CHF]. Per NWD of family and non-family workforces costs of CHF 267 are used[3]. Opportunity costs of arable land, meadows and pastures are assumed to be CHF 672, CHF 673 and CHF 591 per ha, respectively[4].

Table 1: Characteristics of the analysed farms

Variable	Mean	Min.	Max.
LU total	34.2	5.8	127.1
LU in dairy enterprise	31.0	5.0	101.0
Dairy cows	26.0	5.0	95.5
Kg milk per year leaving the enterprise[a]	193’500	30’000	620’900
Kg milk yield per cow and year	7780	4110	14020
UAA [ha]	29.0	10.6	71.3
Grassland [ha]	13.7	4.1	38.1
Meters above sea level	517	308	820
Number of enterprises per farm	10.3	6	16

a) For an explanation why this rather unusual figure is shown here, please refer to section 3.2

[2] Which qualifies them to receive direct payments from the government.
[3] Based on an median yearly income of CHF 74'786 in 2012 in the Swiss plain region and assumed 280 NWD per year.
[4] Based on own calculations evaluating the median land rents in the FADN sample.

Table 2: Subset of enterprises and animal categories used for the joint cost allocation by means of maximum entropy.

Animal husbandry	
Enterprise	*Sub-Enterprise*
Dairy**	Dairy cows* Rearing cattle in the age of 0 to 4 months Rearing cattle in the age of 4 to 12 months Rearing cattle in the age of 12 to 24 months Rearing cattle older than 24 months
Fodder Production Enterprises	
Intensive meadows*' ***	
Middle intensive meadows*' ***	
Pasture ***	
Alpine pasture and meadows***	
Silage maize***	
Grain maize***	
Fodder wheat	
Protein crops***	
Other Gainful Activities (OGA) Enterprises	
Contracting work	
Machinery rental	
Direct marketing	
Other agriculture-related activities	

* Enterprises where economies of scale are assumed
** Enterprises which are responsible for the costs of roughage production on the farm
*** The costs of roughage production are allocated to the enterprises marked with ** according to the number of LU.

Compared with Lips (2014a) in this paper a larger and more detailed set of enterprises including different animal categories denoted as sub-enterprises as well as OGA is used of which a subset is shown in Table 2.

3. Methods

3.1. Maximum Entropy Joint Cost Allocation

Full production costs consist of all direct and joint costs that arise for the production of a good. In the case of Swiss FADN data the direct costs are allocated to the enterprises by the farm manager and his bookkeeper, meaning that they are readily available for calculations. Joint costs, however, are only available at farm level and thus have to be allocated to the enterprises by an appropriate method. This allocation is based on assumptions and could only be verified by scrupulous self-examination of each farmer which would be highly time and cost intensive. Thus, full cost calculations based on FADN data are always to be understood as an estimate without the claim for absolute accuracy.

One way to estimate the joint costs of every single enterprise of a farm is the so-called proportional allocation according to allocation factors such as machinery hours or turnover figures (e.g., Hemme et al., 2014). Standard costs that are available from farm management literature can also serve as allocation factors. Lips (2014b) suggests an allocation model based on maximum entropy and inequality restrictions which allows a disproportionate allocation of full cost items. As a consequence, costs of enterprises with

high standard costs are adjusted in a stronger manner than the costs of enterprises with low standard costs because there is a wider scope to spend and save resources. While Lips (2014b) uses the same set of allocation factors for all farms under consideration, Hoop and Lips (2014) suggested a more differentiated treatment for allocation factors. They vary from farm to farm depending on the size of the enterprise. A size-dependent cost degression is introduced in order to account for economies of scale and a presumably higher degree of rationalisation in large enterprises. For example, if an allocation factor (μ_1) indicates the necessary working days per milking cow for a herd of 10 cows (S_1) and μ_2 refers to 20 cows (S_2), the allocation factor μ_2 is substantially lower than μ_1. Basing on a large set of standard cost calculations for enterprises of different sizes (Zorn et al., 2015), standard costs are assigned to individual enterprises by interpolation (Hoop and Lips, 2014).

In the following application the joint cost allocation is carried out twice. With constant allocation factors (1) and farm-specific allocation factors taking account of economies of scale (2). The effect of this economies of scale assumption on the cost allocation shall be analysed in detail. The comparison of the two applications allows to analyse how the distribution of full costs in the sample changes, and how the assumption of economies of scale influences the results when analysing the determinants of full costs. Generally, including the economies of scale assumption into the model is expected to cause shifts between the enterprises of a farm. For example, if a farm has a large dairy enterprise and some other small enterprises, assuming economies of scale should lower the full costs in the dairy enterprise and increase those of the other enterprises. This effect will be most apparent when a farm has many small enterprises and only one or a few large enterprises.

For all animal husbandry enterprises with sub-enterprises (e.g., different animal categories within the dairy enterprise) the joint cost allocation is done in two steps. First, joint costs are allocated to the sub-enterprises (e.g., dairy cows or rearing cattle of all ages). In a second step, the costs of the sub-enterprises are aggregated to the enterprise-level. It is important to note that the joint cost allocation is done separately for each joint cost item.

3.2. Calculating full costs per kg milk

The maximum entropy model calculates the farm- and enterprise-specific joint costs per size unit. The costs per size unit are multiplied by the number of units in the enterprise and added to the direct costs in order to get the full costs of the enterprise as a whole. The aim is to calculate the full costs per kg milk including all costs for keeping and feeding the cattle of all ages, for milking and for fodder production. Unfortunately, for the sake of simpler accountancy handling, the full costs of the dairy enterprise yet also include the costs for the occasional fattening of cattle. This part of the costs is estimated by the share of revenues that result from selling by-products like calves, breeding cattle or cows for slaughtering (besides the main product milk) and is subtracted from the full costs of the enterprise. The remaining costs are finally divided by the amount of milk that leaves the enterprise (i.e. is not fed within the enterprise for rearing and fattening but is actually sold or sometimes internally delivered to other enterprises within the farm).

3.3. Finding cost determinants and analysing the effect of economies of scale

Based on the full costs per kilogram of milk the determinants are analysed by means of a robust regression analysis. As explanatory variables we use the size of the dairy enterprise measured in LU and the milk yield per cow and year. To cope with non-linear effects we use both linear and squared terms. Cost relevant technical aspects are considered such as cubicle housing system or silage free foodstuff. Furthermore, interactions with other enterprises are addressed such as the share of OGA on total farm revenues (see also Table 4 in the result section). The regression analysis is carried out separately for both maximum entropy allocation models with 1) constant allocation factors and 2) farm-specific allocation factors.

4. Results

Table 4 reports the resulting scattering of full costs per kilogram of milk for both allocation methods by means of percentiles. Without the farm-specific allocation factors, milk production costs range between CHF 0.62 and 2.77, illustrating the diversity of milk production in the sample used. On average the costs are CHF 1.313 which is more than twice the average milk price in 2012 of CHF 0.61 (BLW, 2014). With economies of scale assumption milk production costs range from CHF 0.59 to CHF 2.73 per kilogram. The deviations between the allocation methods is reported in absolute terms and in percentage, respectively. They are in range between -3.5% and +0.7%.

The results of the robust regressions explaining the cost per kilogram of milk are reported in Table 5. Not surprisingly, also the results of the regression analysis don't change markedly when farm-specific allocation factors are used in the maximum entropy model (Table 4 and Figure 1).

Table 3: Full costs of milk production in Swiss Francs per kg with and without economies of scale assumption

	no EoSA[1]	EoSA[2]	Δ (Rp.[3])	Δ (%)
0%	0.617	0.595	-0.022	-3.5%
10%	0.899	0.895	-0.004	-0.5%
20%	1.000	0.992	-0.008	-0.8%
30%	1.078	1.077	0.000	0.0%
40%	1.167	1.168	0.001	0.1%
Mean	1.313	1.312	-0.001	-0.1%
50%	1.276	1.269	-0.007	-0.5%
60%	1.385	1.370	-0.015	-1.1%
70%	1.464	1.467	0.003	0.2%
80%	1.569	1.580	0.011	0.7%
90%	1.784	1.789	0.005	0.3%
100%	2.766	2.730	-0.037	-1.3%

1) Without economies of scales assumption, i.e. with uniform allocation factors (no EoSA)

2) With economies of scales assumption, i.e. with farm-specific allocation factors (EoSA)

Besides the cost decreasing effect of the enterprises size (-2.51 Centimes/LU and +0.01 Centimes/LU^2; figures for EoSA) and the milk yield (-43.00 Centimes/1000kg and +1.92 Centimes/1000kg^2) on production costs, some cost driving factors were found. The silage free production of feedstuff (+13.71 Centimes), high assets in machines, buildings and equipment per LU of farm (+9.11 Centimes/(CHF 10'000 /LU)), animal friendly husbandry (+3.16 Centimes/(CHF 100 direct payments/LU)), a high share of milk fed within the dairy enterprise (+1.44 Centimes/%), a high share of hired workforce on total workforce (+0.47 Centimes/%) as well as the increasing age of the farmer (+0.33 Centimes/year) are significant cost drivers.

Table 4: Results of the regression analysis explaining the full costs of milk production (in Swiss Centimes per kg) with and without economies of scale assumption.

	Estimate (no EoSA[1])	Estimate	Significance (no EoSA[1])	Significance (EoSA[2])
Intercept	344.35	359.54	0.0000 ***	0.0000 ***
Dairy animals in LU	-2.18	-2.51	0.0000 ***	0.0000 ***
Dairy animals in LU (square)	0.01	0.01	0.0023 **	0.0002 ***
Milk yield in 1000 kg per cow and year	-41.83	-43.00	0.0000 ***	0.0000 ***
Milk yield in 1000 kg per cow and year (square)	1.83	1.92	0.0000 ***	0.0000 ***
Silage free feedstuff (binary)	14.98	13.71	0.0001 ***	0.0003 ***
Cubicle housing system (binary)	-1.31	-0.91	0.7134	0.7995
Share of pasture on grassland (%)	-0.06	-0.05	0.4732	0.5971
Assets in machines, buildings and equipment per LU of farm (CHF 10’000 /LU)	9.30	9.11	0.0000 ***	0.0000 ***
Share of expenses for machinery repairs on expenses for machinery repairs + depreciation (%)	0.01	-0.01	0.9041	0.9337
Share of expenses for contractors on expenses for contractors + own machinery (%)	-0.03	-0.04	0.7829	0.7191
Direct payments for animal-friendly husbandry per LU (CHF 100 /LU)	3.21	3.16	0.0114 *	0.0127 *
Share of revenues of by-products on total revenues of dairy enterprise (%)	-0.15	-0.21	0.4208	0.2814
Share of milk fed within the enterprise (%)	1.40	1.44	0.0001 ***	0.0000 ***
Share of revenues from OGA on total farm revenues (%)	0.08	0.01	0.6997	0.9460
Share of hired workforce on total workforce (%)	0.48	0.47	0.0000 ***	0.0000 ***
Share of family workforce in off-farm work on total family workforce (%)	-0.13	-0.14	0.1512	0.1178
Qualification: master or/and university	-3.75	-3.77	0.1911	0.1893
Age of farmer	0.38	0.33	0.0249 *	0.0499 *
R^2	0.74	0.75		
Adjusted R^2	0.72	0.72		
F-Statistics (on 18 and 179 degrees of freedom)	28.70	29.47	0.0000 ***	0.0000 ***

1) Without economies of scales assumption, i.e. with uniform allocation factors (no EoSA)

2) With economies of scales assumption, i.e. with farm-specific allocation factors (EoSA)

On the other hand, the following variables do not significantly influence milk production costs: cubicle housing system (as an indicator for a low labour input system), a high share of pasture on grassland (which was expected to lower costs of fodder production), a high share of expenses for machinery repairs on expenses for machinery repairs + depreciation (as an indicator for mostly depreciated machines on the farm), a high share of expenses for contractors on expenses for contractors

+ own machinery (as an indicator for the degree of outsourcing), the share of revenues of by-products on total revenues of the dairy enterprise (as an indicator for possible cross-subsidisation of the dairy production), the share of revenues from OGA on total farm revenues (which possibly decreases farm efficiency and therefore increases production costs), the share of family workforce in off-farm work on total family workforce (which possibly diminishes the pressure to efficiently produce milk) as well as the qualification of the farm manager (which we would have expected to lower production costs).

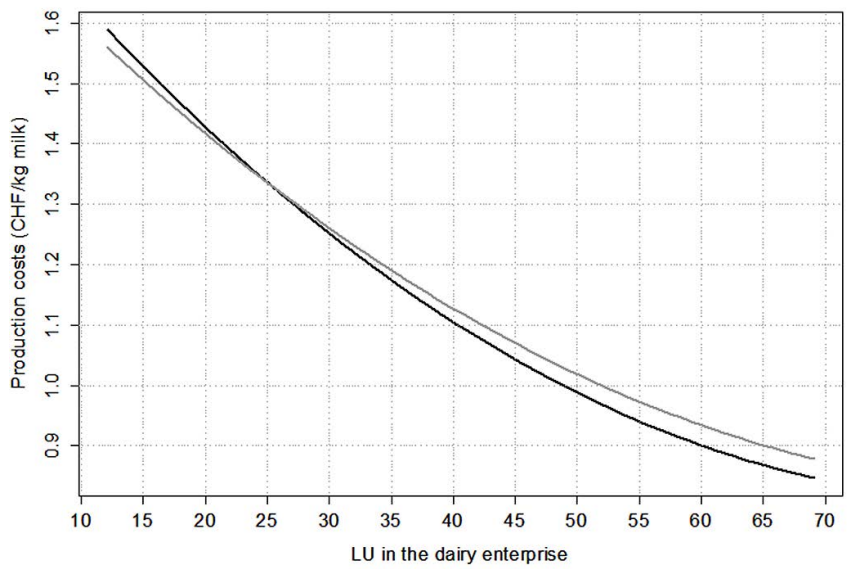

Figure 1: Full costs of milk production depending on the size of the dairy enterprise. Black: Cost degression estimated for the model with economies of scale assumption, i.e. with farm- specific allocation factors. Gray: Cost degression estimated for the model with uniform allocation factors.

5. Discussion and conclusions

In this paper we calculated the single farms' full costs of milk production in the Swiss plain region using a maximum entropy model for joint cost allocation. The average costs of CHF 1.31 /kg[5] are more than twice as high as the producer price for milk and differ substantially between farms. The high variation between farms shows the huge potential to lower production costs in the analysed sample.

The different allocation methods (with and without farm-specific allocation factors resp. economies of scale) have minor impact on the resulting costs per kilogram of milk. This can partly be explained by the importance of direct costs which are not affected by the joint cost allocation. Although the effect of farm-specific allocation factors that account for economies of scale on the results is rather small, it contributes to a more adequate full cost allocation.

As regards the determinants of full costs per kilogram of milk, the size of the enterprise and the milk yield per dairy cow turned out to be important cost decreasing parameters. In this regard, it is important

[5] Unfortunately, this figure cannot be directly compared to the figure that is published by Hemme et al. (2014) because they either correct for all non-milk returns including direct-payments (and calculate milk costs of CHF 1.03 /kg) or they do not correct for any non-milk returns (and calculate milk costs of CHF 1.67 /kg).

to note that the cost decreasing effect of the enterprises size was observed with or without the assumption of economies of scale, i.e. it does not solely result from the assumptions in the joint cost allocation model. Absolutely speaking, assuming farm-specific economies of scale (in the joint cost allocation model) increases the coefficients of the two mentioned parameters and decreases the coefficients of the remaining ones (in the regression analysis).

6. References

BLW, 2014. Marktbericht Milch, März 2014, Bundesamt für Landwirtschaft, Bern.

Haas, T. and Höltschi, M. 2012. Vollkosten-Auswertung 2012 [Full-cost analysis 2012]. Agridea and BBZN Hohenrain, Hohenrain.

Hemme, T., (Ed.), 2014. Dairy Report 2013 for a better understanding of the dairy world, International Farm Comparison Network, IFCN Dairy Research Center, Kiel.

Hoop, D. and Lips, M. 2014. Joint Cost Allocation with Farm-specific Allocation Factors, working paper, Agroscope, Ettenhausen.

Lips, M., 2014a. Calculating full costs for Swiss dairy farms in the mountain region using a maximum entropy approach for joint-cost allocation, International Journal of Agricultural Management, 3(3): 145–153.

Lips, M., 2014b. Disproportionate Joint Cost Allocation at Individual-farm Level Using Maximum Entropy, Poster Presentation, EAAE Congress, August 26-29, Ljubljana, Slovenia.

Zorn, A., Gazzarin, C., Hoop, D. and Lips M. 2015. Standard Costs for Enterprises of Swiss Agriculture, Internal Document of Agroscope, Ettenhausen.