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Evaluating the Competitiveness of Milk Production

The Effect of Joint Cost Allocation Methods

Daniel Hoop, Nadja El Benni

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Summary

The global dairy market is highly competitive and cost versus price comparisons and benchmarking with peers can help identify strengths and weaknesses of a business. However, calculating the cost of milk production is not straightforward because milk production inevitably entails the production of joint products such as calves. Based on theoretical considerations and simulated data sets, this study examines how different methods to allocating joint costs affect the estimated cost of milk production. The first method, subtracting revenues of joint products from the cost of the milk production branch, turns out to be less accurate in the majority of modelled scenarios, compared to the ratio method splitting costs between milk and joint products according to their relative sales values. Even though the subtraction method reflects better the ranking order in true cost of milk production, it overestimates the variability in the majority of cases. Considering all strengths and weaknesses, we conclude that the ratio method is the safer choice for allocating costs of joint products because it bears less potential for biased conclusions. The subtraction method should only be applied when farms need to know their break-even milk price for planning purposes or when the exact ranking between farms is of paramount importance for benchmarking.

1 Introduction

The global dairy market is highly competitive (Kozak et al., 2022) and milk prices have become increasingly volatile over the last two decades (European Commission, 2017a; Hemme, 2018; Reincke et al., 2018). In this competitive market, it is more important to monitor and, if necessary, adjust costs. The comparison of economic performance across peers (i.e., benchmarking) can be the impetus to identify strengths and weaknesses of the business and to take actions to improve economic performance and thrive in competitive markets (e.g., European Commission, 2017b).

For benchmarking and break-even calculations, accountancy data on revenues, costs, and profits are necessary and are usually available at the farm level—therefore comprising different PBs such as dairy, pig, or crop PBs. Without further data preparation, these data can be used for full-cost accounting only by highly specialized farms managing one single PB. However, in an international context, specialized farms are an exception, which is illustrated in the International Farm Comparison Network dairy report of 2018 (Hemme, 2018) by the 125 (or 71%) of all 177 “typical farms” that are involved in beef fattening, cash crops, farm manure, biogas, or other activities. Moreover, all typical farms—even highly specialized dairy farms—record non-milk returns. Hence, virtually all farms need a modus operandi to calculate the cost of milk production, to benchmark against peers or to compare the cost of production with the milk price.

In the case of dairying, the problem of cost allocation turns out to be twofold. First, common costs need to be allocated to the milk production branch (MPB). Second, the joint cost of milk and other products within the MPB need to be disentangled. Generally, joint production describes a process where the production of one good entails the production of one or several other goods. In the MPB, not only milk is produced, but also cows are sold at the end of life, calves may be fattened, and heifers may be raised and sold. If the focus lies on one of these products—e.g., milk being the primary product—the other products are considered secondary or “by-products” (Eidman et al., 2000).

Eidman et al. (2000) discuss a wide variety of relevant aspects for full costing (such as purchased and farm-raised expendable inputs, depreciation, opportunity costs of capital and labor, and many more) but do not mention specific methods to separate costs of joint products. Biddle and Steinberg (1984) provide an overview of joint product cost allocation concepts based on linear and non-linear programming. However, these concepts focus on marginal costs that are crucial to maximize profits in the short term but ignore fixed costs, which are essential for break-even calculations and benchmarking (which are based on average cost).

Jürgens et al. (2013), Lips (2014), Hemme (2018), and the European Commission (2018) use different methods for their empirical analyses, including the distinction between milk and its joint products. For this purpose, Jürgens et al. (2013) and Hemme (2018) use an method that is based on subtracting non-milk revenues from costs, whereas Lips (2014) and the European Commission (2018) use the share of milk revenues in total revenues to isolate the cost of milk production.

Therefore, in empirical dairy literature, cost allocation to joint products is performed by using two different methods. However, neither theoretically nor empirically does existing dairy literature answer the question how these two different methodological methods affect the resulting estimates of the cost of milk production. In this article, we close this gap and focus on methodological aspects to isolate the cost of milk production to answer the question how different methodological methods influence the resulting figures. Not only are we interested in the relation between cost estimates of different methods, but also do we want to understand how they might influence the assessment of competitiveness in dairying and the conclusions drawn from benchmarking.

Therefore, the research questions are:

1. Under which circumstances do different methodological methods yield different results?
2. Does the application of different methods affect the conclusions drawn from benchmarking?
3. Is there a preferable method? If so, which one?

The remainder of this article is structured as follows: Section 2 explains different allocation steps to isolate the cost of milk production and describes how the different methods are compared in the subsequent analysis based on simulated data. In Section 3, we analyze and discuss the effect of the different methods on the cost of milk production, before we summarize and draw conclusions in Section 4.

2 Method

In this study, we refer to the MPB as what involves roughage production, feeding and keeping cattle (e.g., dairy cows, bulls, calves, or heifers), manure handling, cleaning, milking, and all necessary managerial activities such as buying feedstuff or marketing cattle and, if necessary, transporting the milk. The MPB may produce different joint products such as milk, calves, or public goods such as ecosystem services.

On diversified farms, at least two steps are necessary to allocate costs to different joint products of the MPB. First, farm-wide costs are allocated to each PB. Second, costs of the MPB are allocated to each of the joint products. Potentially, this allocation can be done for any given number of joint products, but in our case, we are interested only in the differentiation between milk and non-milk products.

To allocate farm-wide common costs to the MPB (step 1 of 2, cf. previous paragraph), one possibility is to follow the costs-by-cause principle and apply an indirect costing method using standard costs of PBs as auxiliary information to split up the sum of joint costs to individual PBs (see e.g., Langrell et al., 2012; Gazzarin and Lips, 2018). Standard costs are, for instance, labor cost or the cost for buildings that a dairy cow typically causes per year; they are usually available from farm management literature or from consultants. These standard costs can be farm-specific and account for PB characteristics such as size of the PB (economies of scale). Given the standard cost (sc_{pb}) per size unit (such as livestock units or hectares) for all PBs and the sizes (s_{pb}) of all PBs, the hypothetical sum of farm-wide costs (C_{hypo}) can be calculated as:

$$C_{hypo} = \sum_{pb \in PB} sc_{pb} * s_{pb} \tag{1}$$

Knowing the sum of farm-wide costs (C_{real}), the adjustment factor (a) for all standard costs can be calculated as:

$$a = \frac{C_{real}}{C_{hypo}} \tag{2}$$

Thus, the costs (c_{pb}) allocated to each PB result to:

$$c_{pb} = a * sc_{pb} * s_{pb} \tag{3}$$

For highest possible accuracy, this procedure should be applied separately for each common cost item (using different standard costs; see, e.g., Lips et al., 2018).

2.1 Joint Cost Allocation Methods to Estimate Cost and Profit per Kilogram of Milk Sold

To estimate the cost of milk production (or, more generally, to allocate joint costs), we distinguish two methods according to their arithmetic characteristics: the “subtraction method” and the “ratio method”. The subtraction method is described and applied in the yearly International Farm Comparison Network report edited by Hemme (2018). If we assume that revenues from all joint products except milk sold (r_{other}) approximately reflect their cost of production (c_{other}; Equation 4),

$$c_{other} \cong r_{other} \tag{4}$$

then isolated cost of milk production ($c_{milk}^{subtr.}$) can be derived as the total cost of the MPB (c_{dairy}) minus the sum of revenues except those from milk sold:

$$c_{milk}^{subtr.} = c_{dairy} - r_{other} \tag{5}$$

According to Seicht (2001), this is the only reasonable method in case all joint products apart from milk can clearly be classified as by-products. It is also the proper method to apply when the break-even milk price for the MPB *as a whole* is of interest. However, we argue that it should not be used when the cost of milk production should be compared to the milk price, which might be of interest when farmers associations bargain with milk processors. The reason is that Equation 4 usually does not hold true. European family farms, for example, often post (imputed) losses (Hemme, 2018). Using the subtraction method, one assumes that all joint products are produced at break-even, but milk production is responsible for all losses. If this is not true in reality, but also the joint products are loss-making, then the profitability of milk production seems worse than it actually is.[1] If, in a separate situation, Equation 4 does not hold true and if the revenue from non-milk product is greater than the cost of milk production ($r_{other} > c_{dairy}$), then the estimated cost of milk production can even become negative (as is the case for typical International Farm Comparison Network farms of Cameroon, Nigeria, and Uganda; Hemme, 2018). This may appear counterintuitive, but it means that all other activities of the MPB (except the production of milk sold) are so profitable that the MPB (as a whole) does not depend on the revenues from milk sold to make profit. Moreover, even if the MPB needed to pay to dispose of the produced milk, it would still be profitable. However, in such situations it is questionable if estimating the cost of milk production makes sense at all because milk rather seems to be a by-product, not the main product (and therefore one would assume that $c_{milk} \cong r_{milk}$).

The ratio method is based on the assumption that the share of the cost of milk production in total costs is approximately equal to the share of revenues from milk in total revenues of the MPB (Equation 6).

$$\frac{c_{milk}}{c_{dairy}} \cong \frac{r_{milk}}{r_{dairy}} \tag{6}$$

This method takes into account the relative sales value of joint products (Biddle and Steinberg, 1984) and calculates the cost of milk production as follows:

$$c_{milk}^{ratio} = \frac{r_{milk}}{r_{dairy}} * c_{dairy} \tag{7}$$

It is equal to the method based on sales values at split-off point, or, in this special case where there are no further processing costs after the split-off point, it also equals the constant gross margin percentage method (Biddle and Steinberg, 1984). These methods and the ratio method can be applied when the cost (profitability) of different joint products is of interest, whereas the subtraction method only focuses on the main product. In all cases, where the total revenue of the MPB is not equal to the total cost of the MPB, we argue that the underlying assumption of the ratio method (Equation 6) is more reasonable than the assumption of the subtraction method (Equation 4). If, for example, the MPB posts losses, how can we assume that joint products are produced at break-even (as done by the subtraction method), while milk production is loss-making?

In this context, the revenues from direct payments are also relevant. On the one hand, they compensate for non-marketable services of agriculture (which can be interpreted as joint products of milk production). On the other hand, they often incorporate income transfers targeted to increase the income of agricultural households. Disentangling these two aspects is hard, if not impossible, because a program that officially targets non-marketable services may contain hidden elements of income transfer. Therefore, if revenues from direct payments that include income transfers are used as auxiliary information to isolate the cost of milk production, the resulting cost estimates will probably be biased, because neither Equation 4 nor Equation 6 holds true.

Keeping production costs and quantities sold constant, both the ratio and the subtraction method are affected when prices for outputs other than milk change. The ratio method is additionally prone to fluctuations in revenues from milk sold. Ceteris paribus, increasing milk prices increase the cost of milk production estimated by the ratio method, whereas the cost estimated by the subtraction method remains unaffected.

The subtraction and the ratio method yield the same result either if no joint products are produced or if the sum of costs is equal to the sum of revenues of the MPB. If the sum of costs is greater than the sum of revenues, the subtraction method yields higher cost of milk production than the ratio method and vice versa (see Appendix 1 for a formal proof and Table 2 in the results section for an illustration).

For the MPB as a whole, the resulting profit p can be calculated as:

$$p_{dairy} = r_{dairy} - c_{dairy} \tag{8}$$

The profit of milk production, using the subtraction method, is calculated as:

$$p_{milk}^{subtr.} = r_{milk} - c_{milk}^{subtr.} \tag{9}$$

Or, using the ratio method, the profit is calculated as:

[1] One could try to compensate for this disadvantage of the subtraction method by including the profit or loss margin for joint products in their revenue, thus coming closer to the assumption in equation 4. However, this margin would have to be calculated based on a different sample of farms producing only joint products (excluding milk).

$$p_{milk}^{ratio} = r_{milk} - c_{milk}^{ratio} \tag{10}$$

Notice that $p_{milk}^{subtr.}$ and p_{dairy} are identical, which becomes obvious when the subtraction method is written in its expanded form:

$$p_{milk}^{subtr.} = r_{milk} - (c_{dairy} - r_{other}) = r_{dairy} - c_{dairy} = p_{dairy} \tag{11}$$

After having isolated the cost of and profits from milk production, the respective amounts per unit of milk need to be calculated to make them comparable between different MPBs (benchmarking), or to compare the cost with the milk price. Because milk revenues arise from the amount of milk sold, it makes sense to use the amount of milk sold as denominator. It is also possible to use the amount of milk produced as denominator, in which case the revenues per unit of milk are not equal to the milk price. Either way, it is important to use the same denominator for each method to compare all methods consistently. For the sake of comparability, the amount of milk is usually standardized by using measures such as energy corrected milk.

2.2 Comparison of the Joint Cost Allocation Methods

To identify potentially systematic differences and causalities across the cost estimates derived by various costing methods, the present study used nine simulated datasets which differed in two fundamental assumptions. The first assumption was about the average profitability of the MPB as a whole posting a loss, producing at break-even, or posting a profit. The second assumption was about the average relative economic performance of milk production, which can be better, equal or worse compared to the by-products. These assumptions can be combined differently, which results in nine datasets whose characteristics are summarized in Table 1.

Table 1: Average characteristics of simulated datasets

Scenario abbreviation	Total profitability of milk production branch	Relative economic performance of milk compared to by-products	Time development of revenues and costs of milk production
TotalLossMilkWorse1	+ Posting a profit.	− Worse	Rev. + 0.10 / year Cost + 0.05 / year
TotalLossMilkEqual2	+ Posting a profit.	= Equal	Rev. −/+ 0.05 / year Cost +/− 0.05 / year
TotalLossMilkBetter3	+ Posting a profit.	+ Better	Rev. − 0.01 / year Cost – 0.02 / year
BreakEvenMilkWorse4	= Break-even (profit is 0).	− Worse	Rev. +/− 0.10 / year Cost +/− 0.05 / year
BreakEvenMilkEqual5	= Break-even (profit is 0).	= Equal	Rev. −/+ 0.05 / year Cost +/− 0.05 / year
BreakEvenMilkBetter6	= Break-even (profit is 0).	+ Better	Rev. +/− 0.05 / year Cost +/− 0.10 / year
TotalProfitMilkWorse7	− Posting a loss.	− Worse	Rev. – 0.07 / year Cost – 0.015 / year
TotalProfitMilkEqual8	− Posting a loss.	= Equal	Rev. −/+ 0.05 / year Cost +/− 0.05 / year
TotalProfitMilkBetter9	− Posting a loss.	+ Better	Rev. + 0.05 / year Cost + 0.10 / year

In the following, the assumptions of the data simulation are described, which aim to represent the most important scenarios conceivable in reality. To model a MPB with negative profitability, average total costs were assumed 1 CHF per kg milk but total revenues were 0.7 CHF per kg milk. When the profitability was positive, total revenues were 1.3 CHF per kg milk. When the relative economic performance of milk compared to by-products was better, the cost of milk production accounted for 70% of total costs but the revenue from milk production accounted for 80% of total revenues. If the relative economic performance of milk was worse, the revenue from milk production accounted for 60% of total revenues (assumption regarding costs unchanged). Based on these fundamental

assumptions/configurations, a dataset having 20,000 observations was synthesized for each configuration, using Gaussian distributions with a standard deviation of 10% for each variable. In addition, different developments over time were modelled over a period of ten years. In scenarios starting with a loss at the MPB level, the profitability was improved either by disproportionally increasing revenues (TotalLossMilkWorse1, inflationary environment) or by disproportionally reducing costs (TotalLossMilkBetter3, deflationary environment). In scenario TotalLossMilkEqual2, the revenues and costs fluctuated without a direction. Table 1 contains a description of the remaining scenarios. If a clear time trend was assumed (when starting with losses or profits), then the time trend would flip the initial situation from losses to profits or vice versa within approximately five years.
Finally, average values were calculated for each year in each dataset. Based on these yearly averages, the standard deviation was calculated for each dataset, which resulted in the inter-year variability of costs, as opposed to the (intra-year) variability that was calculated for the first year. Based on these data and metrics, it was assessed which method better reflects the true milk production cost and its variability in the sample.

3 Results and Discussion

Throughout this section, the focus is on costs. Because revenues are independent of the chosen method, the inclusion of profits in the analysis would not add value. Table 2 shows the (average) assumptions used in the different scenarios and the resulting (average) cost estimates by the subtraction and the ratio method. In four out of nine possible scenarios, the ratio method yields more accurate estimates. In two scenarios, the subtraction method is more accurate. This is the case when the MPB posts a loss and the relative economic performance milk production is worse than that of by-products (TotalLossMilkWorse1), or when the MPB posts a profit and the relative economic performance of milk production is better than that of by-products (TotalProfitMilkBetter9). In three scenarios where $c_{dairy} = r_{dairy}$, the accuracy does not differ between the methods. Only when both milk production and the production of by-products operate at break-even (BreakEvenMilkEqual5), are the applied methods able to estimate accurately the true cost of milk production. In summary, the ratio method provides more accurate results in most scenarios.

Table 2: Accuracy of cost estimation by different methods in different scenarios

Scenario	Total cost	Revenue to cost ratio	Milk cost share	Milk revenue share	True milk cost	Milk cost (subtraction)	Milk cost (ratio)	More accurate method
TotalLossMilkWorse1	1	0.7	0.7	0.6	0.7	0.72	0.6	S
TotalLossMilkEqual2	1	0.7	0.7	0.7	0.7	0.79	0.7	R
TotalLossMilkBetter3	1	0.7	0.7	0.8	0.7	0.86	0.8	R
BreakEvenMilkWorse4	1	1	0.7	0.6	0.7	0.6	0.6	=
BreakEvenMilkEqual5	1	1	0.7	0.7	0.7	0.7	0.7	=
BreakEvenMilkBetter6	1	1	0.7	0.8	0.7	0.8	0.8	=
TotalProfitMilkWorse7	1	1.3	0.7	0.6	0.7	0.48	0.6	R
TotalProfitMilkEqual8	1	1.3	0.7	0.7	0.7	0.61	0.7	R
TotalProfitMilkBetter9	1	1.3	0.7	0.8	0.7	0.74	0.8	S

S = subtraction method, R = ratio method
Source: own calculations

Table 3 contains the intra-year and inter-year variability in true costs of milk production and the variability in costs estimated by the subtraction and the ratio methods. In addition, the ratio between the inter-year and intra-year variability is shown. In all scenarios, the intra-year variability is better reflected by the ratio method. The subtraction method consistently results in too high intra-year variability. In six of nine scenarios, the subtraction method results in the highest inter-year variability. Only in one case is the variability based on the subtraction method closer to the real inter-year variability. With this one exception, the subtraction method also skews the ratio between inter-year and intra-year variability in an unfavorable fashion.

Table 3: Intra-year and inter-year variability in true costs of milk production and variability in costs estimated by the subtraction (subtr.) and the ratio method. In the table, either an “S” (subtraction) or an “R” (ratio) to the left of the number marks the preferable method.

Scenario	Variable	Intra-year variability	Inter-year variability	Ratio between inter-year and intra-year
TotalLossMilkWorse1	True milk cost	0.10	0.15	1.53
Rev. + 0.10 / year	Milk cost subtr.	0.13	0.08	0.58
Cost + 0.05 / year	Milk cost ratio	(R) 0.09	(R) 0.16	(R) 1.74
TotalLossMilkEqual2	True milk cost	0.10	0.03	0.27
Rev. −/+ 0.05 / year	Milk cost subtr.	0.13	0.04	0.33
Cost +/− 0.05 / year	Milk cost ratio	(R) 0.10	(R) 0.02	(R) 0.21
TotalLossMilkBetter3	True milk cost	0.10	0.06	0.61
Rev. − 0.01 / year	Milk cost subtr.	0.13	0.07	0.57
Cost – 0.02 / year	Milk cost ratio	(R) 0.11	(R) 0.06	(R) 0.61
BreakEvenMilkWorse4	True milk cost	0.10	0.03	0.27
Rev. +/− 0.10 / year	Milk cost subtr.	0.14	0.01	0.10
Cost +/− 0.05 / year	Milk cost ratio	(R) 0.09	(R) 0.03	(R) 0.32
BreakEvenMilkEqual5	True milk cost	0.10	0.03	0.27
Rev. −/+ 0.05 / year	Milk cost subtr.	0.13	0.04	0.32
Cost +/− 0.05 / year	Milk cost ratio	(R) 0.10	(R) 0.02	(R) 0.22
BreakEvenMilkBetter6	True milk cost	0.10	0.05	0.53
Rev. +/− 0.05 / year	Milk cost subtr.	0.13	0.06	0.49
Cost +/− 0.10 / year	Milk cost ratio	(R) 0.11	(R) 0.06	(R) 0.53
TotalProfitMilkWorse7	True milk cost	0.10	0.05	0.46
Rev. – 0.07 / year	Milk cost subtr.	0.15	(S) 0.03	(S) 0.18
Cost – 0.015 / year	Milk cost ratio	(R) 0.09	0.10	1.10
TotalProfitMilkEqual8	True milk cost	0.10	0.03	0.27
Rev. −/+ 0.05 / year	Milk cost subtr.	0.14	0.04	0.31
Cost +/− 0.05 / year	Milk cost ratio	(R) 0.10	(R) 0.02	(R) 0.23
TotalProfitMilkBetter9	True milk cost	0.10	0.30	3.05
Rev. + 0.05 / year	Milk cost subtr.	0.13	0.36	2.78
Cost + 0.10 / year	Milk cost ratio	(R) 0.11	(R) 0.32	(R) 3.06

S = subtraction method, R = ratio method
Source: own calculations

Table 4 contains the rank correlation coefficients for different variables in different scenarios. The cost isolation method exhibiting the highest correlation with the true costs of milk production is preferable. A higher correlation coefficient indicates that the conclusions drawn from benchmarking based on estimated costs match more closely the conclusions drawn from benchmarking based on “true” (simulated) milk costs. The data shows that, in all scenarios, the ranking derived from the subtraction method matches more closely the ranking of true milk costs. The advantage of the subtraction method is more pronounced in the case where the MPBs post a loss on average but not noteworthy in the scenarios in which the MPBs post profits. Interestingly, even in the scenarios in which MPBs produce at break-even and therefore both methods estimate the same cost on average, the ranking resulting from the subtraction method matches more closely the ranking based on true cost of milk production. Mostly independent of the profitability of the whole MPB, the correlation coefficient between the costs estimated by the subtraction and the ratio method ranges between 0.74 and 0.86. It is highest when the relative economic performance of milk production is better than that of the by-products.

Because no correlation between true milk costs and revenues was modelled in the simulated data, the method less correlated with revenues should be preferred. With regard to the revenues from milk, the ratio method exhibits a positive correlation in all scenarios. The correlation is highest in scenarios where the share of revenue from milk is lowest. As expected, there is no such correlation between milk revenues and the cost estimated by the subtraction method. Therefore, the subtraction method is preferable. With regard to revenues from by-products, the subtraction method is preferable in the three scenarios in which the MPB posts a loss, because the absolute correlation between revenues and costs is lower. In the scenarios where the MPB is operating at break-even, the differences in the correlation coefficients are very small which does not allow clear conclusions to be drawn. When the MPB posts a profit, the ratio method shows a lower absolute correlation with the revenues from by-products, which is considered favorable. Overall, the subtraction method shows preferable characteristics with regard to correlations between costs and revenues. Also, when the exact ranking between farms is important for benchmarking, the subtraction method should be preferred, as the costs estimated using this method show the highest correlation with the true cost of milk production.

Table 4: Kendall rank correlation coefficients for different variables in different scenarios. In the table, either an “S” (subtraction) or an “R” (ratio) to the left of the correlation coefficient marks the preferable method.

Scenario	Variable	True milk cost	Milk cost ratio method	Revenue from milk	Revenue from by-products
TotalLossMilkWorse1	MKS MKR	(S) 0.73 0.60	0.74	(S) 0.00 0.25	(S) −0.20 −0.25
TotalLossMilkEqual2	MKS MKR	(S) 0.76 0.66	0.79	(S) 0.00 0.20	(S) −0.15 −0.20
TotalLossMilkBetter3	MKS MKR	(S) 0.79 0.73	0.85	(S) 0.00 0.14	(S) −0.10 −0.14
BreakEvenMilkWorse4	MKS MKR	(S) 0.67 0.60	0.75	(S) 0.00 0.25	−0.27 −0.25
BreakEvenMilkEqual5	MKS MKR	(S) 0.72 0.66	0.80	(S) 0.00 0.20	−0.21 −0.20
BreakEvenMilkBetter6	MKS MKR	(S) 0.76 0.73	0.86	(S) 0.00 0.14	−0.14 −0.14
TotalProfitMilkWorse7	MKS MKR	(S) 0.62 0.60	0.74	(S) 0.00 0.25	−0.34 (R) −0.25
TotalProfitMilkEqual8	MKS MKR	(S) 0.68 0.66	0.79	(S) 0.00 0.20	−0.27 (R) −0.20
TotalProfitMilkBetter9	MKS MKR	(S) 0.74 0.73	0.85	(S) 0.00 0.14	−0.18 (R) −0.14

MKS = milk cost estimated with subtraction method, MKR = milk cost estimated with ratio method,
S = subtraction method, R = ratio method
Source: own calculations

4 Conclusions

In this study, we elaborated on two methods to isolate the cost of milk production from the cost of other joint products (e.g., raising heifers or fattening calves). Theoretical considerations suggest that the two methods estimate identical cost only if the sum of revenues of the milk production branch is equal to the sum of costs of the production branch, i.e., if the production branch's profit is equal to zero, or when no by-products are produced at all. Using simulated data that modelled nine different scenarios it was shown that, on average, the ratio method is more likely to estimate the true cost of milk production. In line with this finding, when a sample of milk production branches is analyzed, the ratio method reflects better the intra-year and inter-year variability of true milk costs while the subtraction method overestimates the variability in the majority of cases. On the other hand, within one year, the costs estimated using the subtraction method correlate more closely with the true cost of milk production. Considering all strengths and weaknesses, we conclude that the ratio method is the safer choice with less potential to draw biased conclusions. The subtraction method should only be applied when farms need to know their break-even milk price for planning (not for bargaining) purposes or when the exact ranking between farms is of paramount importance for benchmarking.

5 Appendix

Condition When Subtraction and Ratio Method Yield Same Result

Setting the cost estimations resulting from both the subtraction (Equation 12, left hand side) and the ratio method (Equation 12, right hand side) equal, we want to derive the conditions under which either one of the methods estimates higher cost of milk production. Hence, we expand

$$c_{milk}^{subtr.} = c_{milk}^{ratio} \tag{12}$$

to

$$c_{dairy} - r_{other} = c_a * \frac{r_{milk}}{r_{milk}+r_{other}} \; . \tag{13}$$

This expansion reformulates to the quadratic equation

$$-(r_{other})^2 - r_{other} * \left(r_{milk} - c_{dairy}\right) = 0 \tag{14}$$

which has two solutions, namely

$$r_{other} = 0 \tag{15}$$

and

$$r_{other} = -\left(r_{milk} - c_{dairy}\right) \; . \tag{16}$$

The second solution can be simplified to:

$$r_{dairy} = c_{dairy} \tag{17}$$

Thus, the subtraction and the ratio method yield the same result either if no joint products are produced or if the sum of costs is equal to the sum of revenues of the MPB. If the sum of costs is greater than the sum of revenues, the subtraction method yields higher cost of milk production than the ratio method, and vice versa.

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7 List of Tables