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Break-even point analysis for milk production – Selected EU countries

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Abstract: Unstable conditions in the milk market in the Czech Republic (CR) and in the European Union (EU), mainly due to volatility of milk prices, are increasing pressure on dairy farmers to maximise production at the lowest possible production costs. Break-even point (BEP) analysis is a useful tool in dairy herd management for determining minimum requirements for profitability. BEP values for milk yield and milk price were calculated based on data obtained from 95 dairy farms in the CR. BEP values were estimated also for another eight EU countries based upon production and cost data from the EU Farm Accountancy Data Network (FADN). With the milk price ranging from EUR 28 to EUR 38 per 100 L and while excluding subsidies, zero profitability would be achieved on Czech dairy farms with milk yields ranging from 6 706 L to 13 151 L per cow and from 7 450 L to 14 088 L per cow in Czech Fleckvieh (C) and Holstein (H) herds, respectively. In order to achieve 5% profitability, the milk yield would need to increase by 21%. Considerable variability exists among EU countries in estimated BEP values depending upon average milk yields, input prices, and milk prices in different countries.

Keywords: cost; economy; milk yield; price; profitability

Milk production plays an important role in the Czech agrarian sector. In 2019, with 361 425 dairy cows (as of December 31) and an average annual milk yield of 8 471 L per cow, the total milk production exceeded 3 billion L (Czech Statistical Office 2020). This accounted for 1.9% of the total milk production across 28 European Union (EU) countries (European Commission 2020). Among the EU states, the Czech Republic (CR) is characterised by long-term above-average milk yield (7th highest in 2019). Achieving reasonable returns in excess of production costs is an important aspect of the future development of dairy farms and securing milk self-sufficiency in the CR. A decision-making tool widely used in dairy herd management is break-even analysis, which assesses the relationship between fixed plus variable costs and revenues. The break-even point (BEP) is defined as a situation wherein an enterprise achieves zero profitability of production, meaning the revenues received for goods are equal to the total costs of their production (Střeleček and Kollar 2002; Horvath et al. 2017). In the dairy farming sector, BEP is usually calculated to estimate the minimum quan-

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tity of milk needing to be produced to cover total costs (Chandra et al. 2014; Singh et al. 2017). As milk yields rise, so do sales and, as has been noted many times, production costs also increase (Němečková et al. 2015). Of the cost items, feed costs are usually considered to be the highest (Michaličková et al. 2014; Glavić et al. 2021). Due to the high volatility of milk prices in CR and in EU countries (Bełdycka-Bórawska et al. 2021), however, there occur significant differences in the economic efficiency of dairy cattle operations over time (Střeleček et al. 2007). There are also marked differences in the price of raw milk between EU member states (Jurkénaité and Mikelionyté 2021). Therefore, in addition to calculating a BEP for milk production, one is often also calculated for the selling price of milk (Krpálková et al. 2017). In this case, the BEP informs about the minimum milk price required to cover full costs (Mach and Rezbova 2009; Kołoszycz 2018). The BEP output price can be used as a simple risk management tool to evaluate the impacts of marketing decisions under conditions of price variability (Dillon 1993). Although BEP can be understood as a minimum profitability requirement, the aim of milk producers is not to achieve zero profit but, rather, to achieve a certain reasonable profitability (Syrůček et al. 2019). BEP values for the milk production sector in the CR previously have been determined using average input parameters (Krpálková et al. 2017; Syrůček et al. 2019). The present study, however, aims to calculate BEP values for different levels of milk yield, milk price levels, and farming areas and thus highlight profitability differences in various milk production conditions of the CR. The second objective of this study was to estimate BEP values for milk yield and milk price in several EU member states.

MATERIAL AND METHODS

Data. Data were obtained from dairy cattle farms located in various regions of the CR for the year 2019 using a questionnaire containing 62 questions structured in five parts: milk production, reproduction and herd turnover, subsidies, diet composition, and yearly costs. Data were collected from a total of 95 dairy farms with an average of 522 cows per farm, thus representing 14% of the Czech dairy cow population. Basic production and economic indicators of the evaluated farms are given in Table 1. Analyses were performed separately for farms having either Czech Fleckvieh (C, n = 39) or Holstein (H, n = 56) cows as well as for those located either in areas with natural constraints (ANC, n = 50) or in areas without any constraints [production areas (PA)] (n = 45).

For model calculations of BEPs in selected EU countries, data from the European Milk Board study (European Milk Board 2021) based upon the EU Farm Accountancy Data Network (FADN) were used. The average selling prices of milk in different countries were obtained from the publicly available database of the European Commission (2020). The calculations were performed for Belgium, Denmark, France, Germany, Ireland, Lithuania, Luxembourg, and the Netherlands. In 2019, these eight countries together produced a combined total of 94 million t of milk, representing 54% and 60% of EU-28 and EU-27 milk production, respectively (European Milk Board 2021). BEPs were also calculated

Table 1. Basic production and economic indicators of Czech dairy farms included in the evaluation

Item	Unit	Czech Fleckvieh (C)			Holstein (H)		
		PA	ANC	all	PA	ANC	all
Number of farms	n	10	29	39	35	21	56
Number of cows per farm	n	455	448	450	564	585	572
Annual milk yield	L per cow	7 537	7 517	7 522	9 592	9 748	9 651
Fat content	%	3.98	4.01	4.00	3.88	3.95	3.91
Protein content	%	3.65	3.60	3.61	3.43	3.46	3.44
Price of milk	EUR per 100 L	34.7	34.9	34.9	34.4	34.3	34.3
Marketability of milk	%	97.57	96.88	97.06	97.06	97.89	97.37
Variable costs	EUR per 100 L	16.62	17.93	17.59	16.71	16.88	16.78
Fixed costs	EUR per cow and year	1 612	1 433	1 479	1 689	1 680	1 685
Secondary outputs	EUR per cow and year	150	151	151	146	145	146
VCS	EUR per cow and year	144	143	144	140	144	142

PA – production areas; ANC – areas with natural constraints; VCS – voluntary coupled support for dairy cows
Source: Own calculations

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$$BEP\ for\ milk\ yield = \frac{Fixed\ costs - secondary\ outputs - subsidies + expected\ profit}{Price\ per\ unit - variable\ costs\ per\ unit} \quad (1)$$

$$BEP\ for\ milk\ price = \frac{Variable\ costs + fixed\ costs - secondary\ outputs - subsidies + expected\ profit}{Market\ milk\ production} \quad (2)$$

where: *BEP* – break-even point

for the average of 26 EU countries, excluding Greece and Cyprus, with the United Kingdom.

Methods. Total costs were the sum of variable costs (concentrated and roughage feed; veterinary and breeding services, including insemination costs) and fixed costs (labour, depreciation of assets and animals, insurance, repairs and maintenance, energy, overheads, and other costs). Secondary outputs of animal production were defined as the value of calves and manure in the Czech farm evaluation, whereas in the EU countries evaluation, according to the methodology of the European Milk Board study (European Milk Board 2021), they represented the production value of beef. The value of secondary outputs was deducted from total costs and this value was then termed 'costs after deduction'. Profitability was determined as a ratio of profit and total costs. The BEPs, defined as the points at which costs and revenues are equal, were estimated for annual milk yield per cow and milk price. In addition, the levels of milk yield and milk price at which profitability of 5% and 10% would be reached were also calculated. The calculations were based upon Equations (1, 2).

Only subsidies in the form of direct payments provided from EU funds were included in the analysis. The Czech BEPs were calculated either with or without voluntary coupled supports (VCS) for dairy cows, whereas the Common Agricultural Policy payments from the EU relevant to milk production were taken into account in EU countries' evaluations. Other (especially national) subsidies were not considered, mainly due to different payments in various member states and the public unavailability of some data. The BEPs in the CR were calculated using milk prices ranging from EUR 28 to EUR 38 per 100 L and using milk yields ranging from 5 000 L to 9 000 L and from 7 000 L to 11 000 L of milk per cow per year for the C and H breeds, respectively.

Where appropriate, the following currency exchange rate was used corresponding to the average rate in 2019 as reported by the Czech National Bank: EUR 1 = = CZK 25.672. A coefficient of 1.027 was used to convert L to kg of milk. All calculations were performed in Microsoft Excel 2019.

RESULTS AND DISCUSSION

BEPs for annual milk yield. With subsidies excluded and in model scenarios with milk prices ranging from EUR 28 to EUR 38 per 100 L, the BEPs for the annual milk yield in the CR ranged between 6 706 L and 13 151 L for C breeds and between 7 450 L and 14 088 L for H breeds (Table 2). When the VCS were included, BEPs for the annual milk yield of C and H breeds decreased on average by 1 012 L and 940 L (i.e. by 11% and 9%), respectively. The BEPs calculated with the subsidies either excluded or included differed less in model scenarios reflecting higher milk prices. Unlike for H herds, the zero profitability requirements were lower for C herds located in the ANC than in the PA due to lower fixed costs. Regardless of breed, the BEP differences between the ANC and PA were greater in models with increasing milk prices. When the milk prices actually achieved in 2019 were considered (EUR 34.85 and EUR 34.32 per 100 L for C and H, respectively), the BEP without subsidies for C was higher (7 928 L) than the actual milk yield (7 522 L) while for H it was lower (9 013 L) than the actual milk yield (9 651 L). This means that under the model conditions in a particular year the H herds were on average profitable (earning EUR 66 per cow and year) while the C herds generated an average loss of EUR 107 per cow and year.

Regardless of breed and with the milk price and production costs actually achieved in 2019, the BEPs without subsidies varied between 5 272 L and 13 281 L per cow per year on 90% of those farms analysed. Thirty-five per cent of them had BEPs for milk yield between 7 000 L and 9 000 L (Figure 1). There was a strong correlation between BEP and the level of total production cost per cow and year and per L of milk ($r = 0.869$ and $r = 0.755$, respectively, $P < 0.001$).

The BEPs for milk yield observed in the present study were broadly in agreement with those of Krpálková et al. (2017), who reported an average BEP of 8 397 L based upon data from Czech farms for the period 2006–2014, and those of Syrůček et al. (2019), who calculated average BEPs of 7 257 L and 9 209 L for

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Table 2. Break-even points (BEP) for annual milk yield estimated for Czech Fleckvieh and Holstein breeds located in different PA of the Czech Republic at different milk price scenarios

Subsidies	Price of milk (EUR per 100 L)	Czech Fleckvieh (C)			Holstein (H)		
		PA	ANC	all	PA	ANC	all
		(L per cow and year)			(L per cow and year)		
VCS excluded	28	13 170	13 142	13 151	14 078	14 108	14 088
	30	11 202	10 965	11 031	11 959	11 956	11 957
	32	9 745	9 406	9 499	10 395	10 374	10 386
	34	8 624	8 235	8 341	9 192	9 162	9 180
	36	7 734	7 324	7 435	8 239	8 204	8 225
	38	7 010	6 594	6 706	7 465	7 427	7 450
VCS included	28	11 873	11 672	11 729	12 796	12 787	12 791
	30	10 098	9 738	9 838	10 870	10 837	10 856
	32	8 785	8 353	8 472	9 448	9 403	9 430
	34	7 774	7 314	7 439	8 355	8 304	8 335
	36	6 972	6 504	6 631	7 489	7 435	7 468
	38	6 320	5 856	5 981	6 786	6 731	6 764

PA – production areas; ANC – areas with natural constraints; VCS – voluntary coupled support for dairy cows
Source: Own calculations

C and H, respectively, based upon data obtained for the period 2012–2018. Slightly lower BEPs reported in previous studies may be due to different assessment periods, thus reflecting the effects of inflation and increased input prices of agricultural production.

In order to achieve 5% or 10% profitability, the average annual milk production of cows would need to increase considerably (Figure 2). For instance, 10% profitability at the milk price of EUR 34 per 100 L would require the increase of milk yield by 1 760 L and 1 970 L per cow (i.e. by 21.1% and 21.5%) in C and H herds, respectively.

Compared to the results presented in this study, BEPs for milk yield estimated in Germany were markedly higher. The average BEP calculated without subsidies based upon the data from 870 herds located in Schleswig-Holstein in 2019 was 13 639 L at a milk price of EUR 35.56 per 100 L (Junge 2020). The difference was mainly due to 19% higher total costs per cow and year and especially due to 70% higher feed costs in Germany. At this milk price, the BEP in the CR would have been only 8 418 L. A somewhat lower BEP of 8 439 L than that reported in the present study, due to higher fixed costs, was reported by Horvath et al. (2017) based upon data from 4 845 H cows in Hungary over the period 2000–2016.

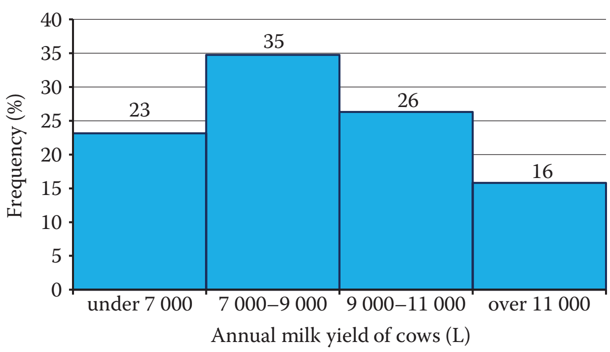

Figure 1. Frequency of break-even points (BEP) for annual milk yield on Czech farms in 2019 [voluntary coupled supports (VCS) excluded]

Source: Own calculations

The BEP for annual milk yield estimated as an average of 26 EU countries in 2019 at the average milk price of EUR 34.76 per 100 L (European Commission 2020) was 13 486 L (Table 3). BEPs for the 8 EU countries evaluated in the European Milk Board study (European Milk Board 2021) ranged between 5 901 L per cow and year (Ireland) and 19 386 L per cow and year (Lithuania). In Ireland, the lowest variable and fixed costs, as well as the highest production value of beef, were observed. For Lithuania, on the contrary, high fixed costs and especially labour costs were reported. Also recorded there was one of the lowest milk prices among all the EU countries. To reach zero profitability, the average milk yield would have to increase in all those countries analysed. Only a small increase would be required in Ireland, however, whereas a milk yield more than three times higher than the actual one would

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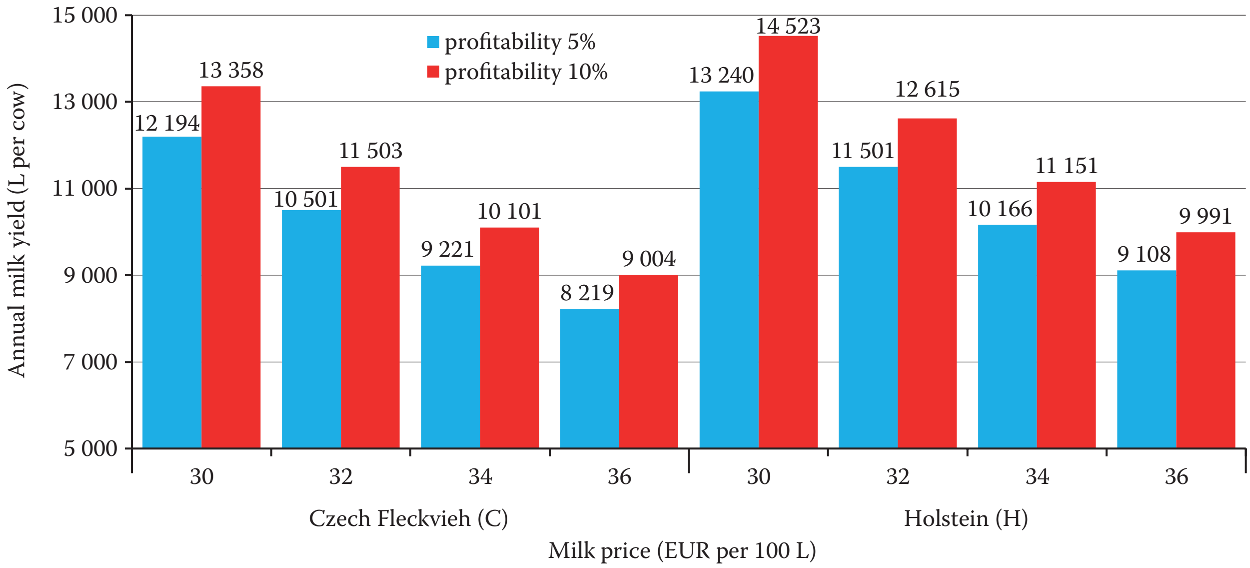

Figure 2. Annual milk yields necessary to achieve 5% and 10% profitability on Czech farms with Czech Fleckvieh and Holstein cows under different milk price scenarios [voluntary coupled supports (VCS) excluded]

Source: Own calculations

be needed in Lithuania. In comparison with the average BEP for Czech farms in 2019 (7 732 L per cow and year regardless of breed and including VCS payments), the BEPs calculated for the selected EU countries were, with the exception of Ireland, markedly higher due to higher overall input costs in these countries.

The average milk yield in the EU would need to increase by 1 271 L and 2 542 L per cow and year to achieve 5% and 10% profitability, respectively.

Table 3. Break-even points (BEP) for milk yield in different EU member states at different profitability and total costs level scenarios (L per cow and year)

Country	Average annual milk yield	Milk yield at different levels of profitability		
		0%	5%	10%
Belgium	7 723	15 480	16 801	18 122
Germany	7 704	15 789	17 253	18 718
Denmark	9 562	14 470	15 857	17 245
France	6 707	13 917	15 096	16 275
Ireland	5 729	5 901	6 469	7 037
Lithuania	5 501	19 386	20 754	22 122
Luxembourg	7 727	12 065	13 197	14 329
Netherlands	8 642	12 815	13 862	14 908
EU* average	7 039	13 486	14 757	16 028

*26 EU member states, excluding Greece and Cyprus, with the United Kingdom

Source: Own calculations based upon data from European Milk Board (2021)

BEPs for milk price. On Czech dairy farms with an average annual milk yield between 5 000 L and 9 000 L, the BEPs for milk price would range between EUR 45.50 and EUR 33.33 per 100 L in C and between EUR 39.82 and EUR 31.60 per 100 L in H (Table 4). A 1 000 L increase in milk yield would reduce the milk price necessary to cover total costs on average by EUR 3.04 and EUR 2.05 per 100 L for C and H breeds, respectively. The differences between the PA and the ANC were markedly higher in C farms, with higher BEPs for milk price in PA locations due to greater fixed costs. With VCS included, the BEPs for milk price decreased by EUR 2.11 and EUR 1.66 per 100 L in C and H breeds, respectively, and the influence of supports diminished as milk yields increased. According to the International Committee for Animal Recording (2020), the average milk yields recorded for C and H in the CR in 2019 were 7 457 L and 9 811 L. Based upon the present data, these yields would correspond to BEPs for milk price of EUR 36.48 and EUR 33.35 per 100 L, respectively. Thus, the BEP for the C breed was higher than the average milk price of EUR 33.53 per 100 L actually paid in the CR in 2019 (European Commission 2020).

The average BEP for milk price calculated for Czech farms regardless of the breed was EUR 34.68 per 100 L (VCS excluded), and it fluctuated between EUR 28.04 and EUR 41.36 per 100 L in 90% of those dairy operations evaluated. With VCS excluded, 53% of farms were profitable as they sold milk for prices higher than the BEP and 26% of farms even achieved profitability

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Table 4. Break-even points (BEP) for milk price estimated for Czech Fleckvieh and Holstein breeds located in different PA of the Czech Republic at different milk yield scenarios

Subsidies	Czech Fleckvieh (C) annual milk yield (L per cow and year)	PA (EUR per 100 L)	ANC (EUR per 100 L)	all (EUR per 100 L)	Holstein (H) annual milk yield (L per cow and year)	PA (EUR per 100 L)	ANC (EUR per 100 L)	all (EUR per 100 L)
VCS excluded	5 000	47.01	44.98	45.50	7 000	39.92	39.65	39.82
	6 000	42.01	40.56	40.94	8 000	37.08	36.85	36.99
	7 000	38.45	37.41	37.68	9 000	34.88	34.67	34.80
	8 000	35.77	35.05	35.23	10 000	33.11	32.93	33.04
	9 000	33.69	33.21	33.33	11 000	31.66	31.50	31.60
VCS included	5 000	44.06	42.01	42.54	7 000	37.85	37.55	37.74
	6 000	39.55	38.10	38.47	8 000	35.27	35.02	35.17
	7 000	36.34	35.30	35.56	9 000	33.27	33.04	33.18
	8 000	33.92	33.20	33.38	10 000	31.66	31.46	31.59
	9 000	32.05	31.57	31.69	11 000	30.35	30.17	30.28

PA – production areas; ANC – areas with natural constraints; VCS – voluntary coupled support for dairy cows
Source: Own calculations

of at least 10%. With VCS included, the BEP decreased by 10%, 59% of farms were profitable, and 39% of farms exceeded the 10% profitability level.

Milk prices that would have been necessary to achieve 5% and 10% profitability on Czech farms are shown in Figure 3. It is clear that for most milk yield scenarios the milk price would need to be considerably higher than that actually paid.

Due to constantly increasing milk production costs, the values presented here are only slightly higher than the BEPs for milk price reported for the Czech farms in previous studies. The average BEP for milk price of EUR 32.95 per 100 L was calculated based upon data from 2006 to 2014 (Krpálková et al. 2017), whereas the BEPs calculated for the period from 2012 to 2017 separately for C and H breeds ranged between EUR 30 and EUR 34 per 100 L and between EUR 29 and EUR 32 per 100 L, respectively (Syrůček et al. 2019).

Markedly higher BEPs for milk price compared to the present study due to higher production costs

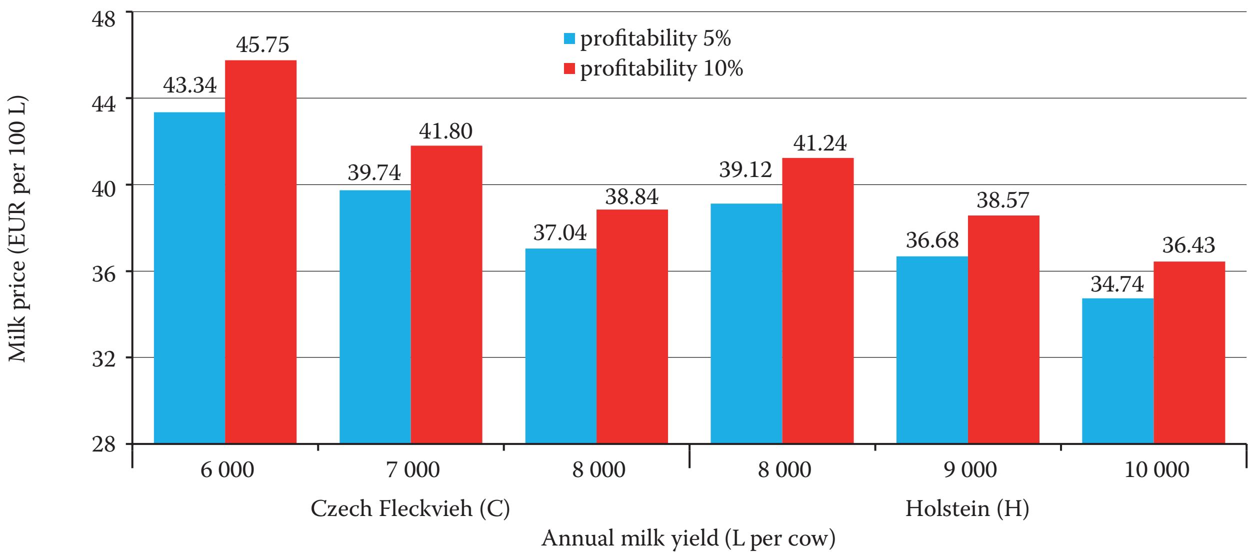

Figure 3. Milk prices necessary to achieve 5% and 10% profitability on Czech farms with Czech Fleckvieh and Holstein cows under different milk yield scenarios [voluntary coupled supports (VCS) excluded]

Source: Own calculations

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were recorded in Germany. The BEP determined for dairy operations in Schleswig-Holstein in 2019 was EUR 43.96 per 100 L (Junge 2020).

The actual milk prices paid in various EU countries, BEPs for milk price, and the milk prices necessary to achieve 5% and 10% profitability are presented in Table 5. Varying BEPs among countries were due to markedly different fixed costs and annual milk yields per cow. The lowest BEP was determined for Ireland with the actual milk price only 1.5% lower than the calculated milk price BEP. It corresponded with the lowest fixed costs recorded in Ireland. On the contrary, the highest milk price necessary to achieve zero profitability was observed in Lithuania due, somewhat unexpectedly, to high labour costs. This was probably because of a relatively large number of family members working on small dairy farms with a low total milk yield (European Milk Board 2021). Labour costs were high also in Denmark but the BEP for milk price was even below the EU average due to that country's high milk yields. The average BEP for milk price calculated for the whole EU was 34% higher than the actual average milk price paid in 2019. Similar conclusions regarding milk prices, actually paid, being lower than the BEPs for milk price were reported by Kołoszycz (2018) based on the economic results of 124 dairy farms in various EU countries. In the previous European Milk Board study (European Milk Board 2019), the total milk production costs were recorded for Belgium, Denmark, Germany, France, Luxembourg, and the Netherlands. When the BEPs for milk price were calculated using the same approach, they were on average 8.08% lower compared to those presented in this study due to lower total costs in 2017.

Table 5. Break-even points (BEP) for milk price in different EU member states at different profitability and total costs level scenarios (EUR per 100 L)

Country	Average milk price in 2019	Milk price at different levels of profitability		
		0%	5%	10%
Belgium	33.94	48.04	50.45	52.85
Germany	35.27	48.72	51.16	53.59
Denmark	35.03	42.56	44.69	46.81
France	37.46	53.96	56.66	59.35
Ireland	34.60	35.13	36.89	38.65
Lithuania	29.66	60.21	63.22	66.23
Luxembourg	35.15	43.47	45.65	47.82
Netherlands	36.62	45.74	48.03	50.32
EU* average	34.76	46.57	48.90	51.23

*26 EU member states, excluding Greece and Cyprus, with the United Kingdom

Source: European Commission (2020) and own calculations based upon European Milk Board (2021) data

CONCLUSION

Break-even analysis determines the point at which production becomes profitable, and it is frequently used in agricultural enterprises. When the VCS were not accounted for, the BEPs for annual milk yield calculated for C and H herds in the CR in 2019 were 7 928 L and 9 013 L, respectively, and the BEPs for milk price were EUR 36.48 and EUR 33.35 per 100 L, respectively. Thus, the BEPs for both milk yield and price were higher than the milk yields and prices actually obtained, a slight profit was generated only in H herds, while a certain level of subsidies was necessary to achieve profitability in C herds. The level of profitability was markedly influenced by milk price, as model calculations revealed that an increase in milk price by EUR 1 per 100 L would decrease the BEPs for milk yield by 432 L and 487 L per cow and year in C and H herds, respectively. In this study, the economic indicators differed only slightly between PA and ANC. The results revealed marked differences between the CR, selected EU countries, and the EU average in terms of BEPs for milk yield and price. This mainly was due to differences in total costs (feeds, labour, investments, etc.) and milk yields. The disparity between the calculated BEPs and the indicators actually achieved demonstrates the importance of support payments that compensate for the losses incurred and give farmers the desired profit motivation to continue their activities.

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