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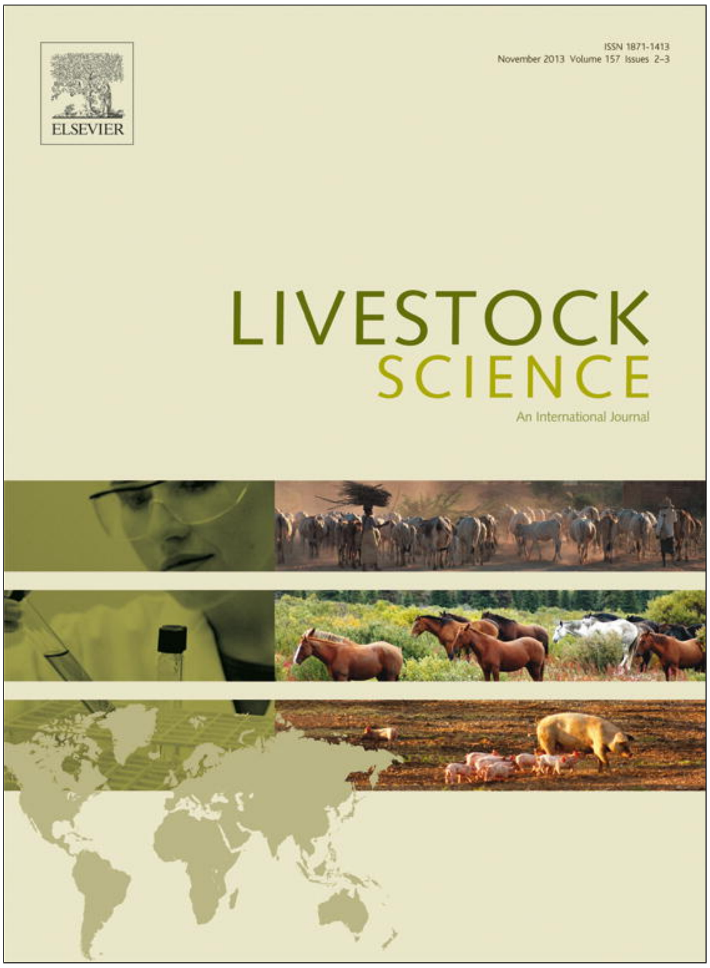

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Economic values for yield, survival, calving interval and beef daily gain for three breeds in Slovenia

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Breeding indices need to be looked at periodically to evaluate the objective of the breeding program. In recent times the economic perspective of the breeding program has received a higher priority in deciding breeding objectives than in the past. However, prices of input and output products are becoming more difficult to predict with increased fluctuations in most prices, which adds a level of complexity to their inclusion in the selection index. With these challenges in mind, the breeding program in a new EU country (Slovenia) was evaluated. All three national Breeding Associations joined the deliberations. The aim of this study was to develop an economic selection index for three breeds (Simmental, Brown Swiss and Holstein-Friesian) in Slovenia. Because farming circumstances differ within Slovenia, differences in the production systems were also taken into account; e.g., flat land vs. hilly/mountainous areas, and for conventional vs. organic farming. Economic values (€) were calculated for milk, fat and protein yields (€/cow/year/kg), survival (€/cow/year/%survival), calving interval (€/cow/year/day), and beef daily gain (€/cow/year/kg). Economic values were calculated by changing one of these traits whilst keeping the other traits at the default level. Economic indices were calculated using a farm economic model (Moorepark Dairy Systems Model). Herd parameters (e.g., number of milking cows, replacements, young stock and calving pattern), milk production, feed requirements and ration, land use and labour requirements were re-parameterised in order to be relevant to the Slovenian circumstances. Absolute economic values were slightly negative for milk yield for all breeds (−0.02 to −0.04€ per kg milk), but positive for milk components (0.55 to 1.45€ per kg fat, and 2.89 to 3.38€ per kg protein). High absolute economic values were calculated for survival (7.37 to 9.55€ per %). Absolute economic values for calving interval were approximately −1€ per day for all breeds, while the economic value for beef daily gain was 0.14€ per kg for Brown Swiss and 0.32€ per kg for Simmental. The constructed economic indices ranked bulls in a significantly different manner than how the Slovenian Total Merit Indices ranked the bulls. The economic indices were robust towards changes in prices and farming system. Ranking was most sensitive towards variation in milk price. Assumptions concerning feed intake in relation to growth influenced the economic value for beef daily gain. Assumptions regarding the farming system (i.e., organic farming systems) only slightly affected the ranking of the bulls.

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1. Introduction

The goal of a breeding program will likely change over time along with the trait focus and the economic perspective, and as a consequence, the traits included in a

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selection index will also change. In this context, breeding indices are continually being developed and evaluated as new technologies and information become available (Shook, 2006). In recent times some model input prices have become much more difficult to predict because of highly fluctuating prices. This adds a challenge to the inclusion of economic values into the selection index. Also the optimum farming system may change and differ between farmers and regions, therefore affecting the composition of an economic selection index.

The changes in the socio-economic environment are even more stringent for Eastern Europe. The new EU countries are still in a state of transition to the market structure of the Western world (Peters et al., 2009). It is therefore an additional challenge to deal with price uncertainty and inclusion of economic values in the breeding program in those countries. For this reason, the new EU country Slovenia was chosen as a case study. Traditionally, the selection index in Slovenia was a Total Merit Index (TMI) that included between 18 and 30 traits (depending on the breed and specialisation (i.e., either milk or beef)). Traits in the TMI are grouped in four categories: (1) milk production, (2) fertility and calving ease, (3) conformation and (4) beef (Klopčič and Kuipers, 2009). Having a large number of traits in an index, results in small genetic gain in each trait (Falconer and MacKay, 1996; Hazel, 1943). Furthermore, the current economic values were not determined based on economic calculations, but were established by a small group of experts based on common sense, strategy and experience in cattle breeding (Klopčič and Kuipers, 2009). A survey of Slovenian dairy farmers carried out in 2005/2006 indicated that farmers had increasing interest in functional traits, like longevity (Klopčič et al., 2006; Klopčič and Kuipers, 2009; Klopčič et al., 2010a). An improvement in a functional trait like longevity increases the efficiency of an animal, not only by higher output of products, but mainly by reduced input costs (Groen et al., 1997).

Some authors (Dempfle, 1992; Groen et al., 1997; Lawrence et al., 2009) pointed out that in addition to economic reasons for including functional traits in the breeding programs, there are also other reasons that favour including them in the breeding program. This relates to ethical, animal welfare and consumer concerns, and to environmental aspects (e.g., greenhouse gas emissions) and food quality and safety (O'Brien et al., 2010). Also the economic situation in the dairy sector requires that breeding goals and selection indices are reviewed on an on-going basis.

Ideally, traits in the breeding goal should encompass all costs and returns associated with a change in each trait. For example, higher levels of infertility would result in a higher level of involuntary replacement, slippage in calving pattern, veterinary intervention, hormonal treatment and reduced annual milk production (Esslemont and Peeler, 1993). Traits in the selection index should identify genetic variation in these breeding goal traits most accurately. However, choice of goal and index traits for fertility is dictated by data availability. Routine recording of index traits is required for evaluations, and a representative sample of data is required to estimate genetic parameters for associations between index and goal traits.

In Slovenia, the intervals between successive calvings are routinely available. However, calving interval includes only animals with a following calving; animals with the worst fertility have no calving interval. For this reason, a simultaneous analysis of calving interval and longevity was proposed. Animals that appear in the data did have a calving interval and animals that do not re-appear were identified as being culled (for many reasons, including fertility). Hence, breeding values for longevity (probability of surviving to the next lactation) and calving intervals were estimated simultaneously and were expected to cover most of the genetic variation in fertility that can be covered from calving dates.

The objective of this study was to develop and evaluate economic selection indices under price-uncertainty in an environment in transition. For this purpose, economic values for milk, fat and protein yield, calving interval, survival, and beef were derived for three breeds in Slovenia (Holstein-Friesian, Simmental and Brown Swiss). As farming circumstances differ (Bergevoet et al., 2010), the derivation of economic values in this study included a number of different scenarios to take in account differences in the farming systems; flat land vs. hilly/mountainous (less favourable) areas, and conventional vs. organic farming. To indicate the impact of adopting an economic index instead of the current Slovenian TMI, the changes in the ranking of the bulls in all scenarios were investigated.

2. Material and methods

2.1. General assumptions

There are several perspectives which can be taken in deriving economic values, for example cost minimisation or profit maximisation at the producer level (Groen et al., 1997; Harris, 1970). Just like in Veerkamp et al. (2002), economic values in the present study were derived from the individual producer's viewpoint, because the producers are the major decision makers with regard to breeding choices in the dairy sector (Groen, 1989b; Pearson, 1986). The perspective of individual producers will be profit maximisation (Groen, 1989a; Moav, 1973). Therefore, this study was limited to the microeconomics of an individual farm. Following others (Bekman and Van Arendonk, 1993; Gibson, 1989; Groen, 1989b), the total annual profit in Euros (€/year) of a dairy herd (T) could be described as follows:

$$T = N(R - C) - c_f$$

where N = number of lactating cows, R = average revenues (€ per cow per year), C = average costs (€ per cow per year) and c_f = fixed costs of farm (for more details see Pieters et al. (1997)). Revenues and costs included in the model were based on an economic study of the Slovenian situation (Kavčič et al., 2009). The major revenues were milk and livestock sales; most costs included were a function of the number of cows, their yield and calving pattern. The values corresponded to a farm situation with either Holstein-Friesian, Brown Swiss or Simmental cows using average production and prices. Overviews of the simulated herd parameters for the three breeds are given in Table 1.

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Table 1
Default parameters for herds with Holstein-Friesian cows for twelve months of a year, with the average for herds with Holstein-Friesian (HF), Brown Swiss (BS) and Simmental (SIM) cows.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Avg HF	Avg BS	Avg SIM
Animals present															
# Milking + dry cows	20.78	20.76	20.75	20.67	20.62	20.60	20.58	20.60	20.61	20.63	20.68	20.74	20.67	14.51	17.57
# Calves	11.48	11.48	11.48	11.48	11.47	11.47	11.47	11.47	11.47	11.47	10.43	11.48	11.39	12.27	17.15
# Yearlings	10.38	10.38	10.50	10.44	10.36	10.38	10.29	10.32	10.30	10.25	10.24	10.26	10.34	9.87	13.40
Total Livestock Units	31.24	31.25	31.35	31.31	31.27	31.32	31.27	31.28	31.26	31.16	31.12	31.14	31.25	24.89	31.76
Animal sales and purchases															
# Cows died	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.02	0.03
# Cows culled	0.44	0.44	0.44	0.44	0.44	0.44	0.44	0.44	0.44	0.44	0.44	0.44	0.44	0.25	0.30
# Male calves sold	1.06	0.93	0.93	0.81	0.86	0.94	0.92	1.02	0.99	1.01	1.06	1.07	0.97	0.33	0.16
# Female calves sold	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
# Replacements sold	0.90	0.90	0.78	0.83	0.91	0.89	0.98	0.96	0.98	1.03	1.04	1.02	0.94	0.63	0.77
# Replacements purchased	0.55	0.48	0.48	0.42	0.44	0.49	0.48	0.52	0.51	0.52	0.55	0.55	0.50	0.27	0.32
Milk production															
Milk produced (kg)	13,235	12,289	13,767	13,490	13,561	12,684	12,747	12,424	11,878	12,195	11,965	12,743	12,748	6830	7685
Milk fed to calves (kg)	222	194	202	182	179	175	191	199	198	209	206	219	198	250	316
Butterfat sales (kg)	535	496	554	532	528	494	502	500	489	511	496	519	513	275	310
Protein sales (kg)	424	391	438	431	431	401	406	404	392	405	394	414	411	225	248
Feed requirements															
Grass cows (kg DM)	0	0	0	1242	2978	3191	3182	3029	2958	1471	0	0	1504	2374	3188
Concentrate cows (kg DM)	5963	5665	6385	5568	4473	3887	4084	4197	4032	5115	5508	5760	5053	541	597
Silage cows (kg DM)	2937	2441	2674	1242	0	0	0	0	0	1471	2937	3041	1395	1968	2734
Total demand grass (kg DM)	0	0	0	2183	4911	5066	5101	4949	4810	2421	0	0	2453	3270	4399
Total demand silage (kg DM)	5782	5022	5566	3126	989	961	998	987	951	3394	5697	5876	3279	3832	5340
Land use															
Total area closed for silage (ha)	0.00	0.00	4.85	4.85	4.85	3.24	3.24	3.24	0.00	0.00	0.00	0.00	2.02	2.36	3.29
Area available for grazing (ha)	6.17	6.17	1.31	1.31	1.31	2.93	2.93	2.93	6.17	6.17	6.17	6.17	4.15	5.30	7.21
Area cut for silage (ha)	0.00	0.00	0.00	0.00	4.85	0.00	3.24	0.00	0.00	0.00	0.00	0.00	0.67	0.79	1.10
Grass growth utilised (kg DM per ha)	0	0	0	1523	2408	2113	1720	1315	974	520	0	0	881.08	881.08	881.08
Labour requirements															
Milking (hours per day)	2.7	2.7	2.7	2.7	2.7	2.7	2.6	2.6	2.6	2.6	2.6	2.6	2.65	2.93	3.11
# cows related work (h/d)	0.76	0.76	0.76	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.76	0.75	0.53	0.64
Fixed labour (h/d)	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.60	2.60	2.60
Labour per month	188.0	170.2	188.8	182.7	188.0	181.4	186.7	186.4	180.1	186.0	180.3	187.0	183.80	185.55	194.55

2.2. Bio-economic model

The bio-economic model for Ireland, i.e., Moorepark Dairy Systems Model (Shalloo et al., 2004), was used as a base and adjusted to Slovenian prices and costs to derive the economic values for the Slovenian breeds. In short, this model included effects of herd performance, lactation curves, feed requirements, land and capital (with depreciations), labour costs, other costs, and payment systems. Details of the model and its parameters were described by Veerkamp et al. (2002).

The herd performance was simulated based on groups of cows calving in the middle of the month (Jan–Dec), and within these groups no allowance was made for different age or parity classes. The model assumed that 45% of the female calves were reared for replacements. For Holstein-Friesian, all male calves were sold within one month of age. For the dual purpose breeds (Brown Swiss and Simmental), half of the male calves were sold at 10 weeks (120 kg), and the other half were reared for 21 months and slaughtered at 600 kg of live weight. These differences in selling regimes between breeds are accounted for in the bio-economic model.

Lactation curves for milk yield and milk composition (fat, protein and lactose percentage, F%, P% and L%, respectively) were obtained from Slovenian national test-day milk recordings.

Feed requirements were calculated monthly for milking cows using the metabolisable energy (ME) system (AFRC, 1993). Metabolisable energy for milk production was calculated as well as for maintenance, pregnancy and per kg of live weight gain or loss. Finally, ME requirements were increased by 5% to allow for spillage and leftovers. The simulated feeding regime had fixed ratios of grass,

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silage and concentrate for each month of the year. The amount of feed offered was altered to meet energy requirements. Metabolisable energy content of silage and concentrate were 9.5 and 12.5 MJ/kg dry matter (DM), respectively. The ME content of grazed grass varied from 12.3 MJ/kg DM in March to 11.4 MJ/kg DM in November.

The assumptions for grazing, grass production and silage harvesting were made according to Slovenian circumstances, with a total yearly grass harvest of 12.98 t of dry matter per hectare. The land area for first and second cut silage (ratio 3:2), and for grazing were optimised to meet silage and grass requirements. Costs for fertiliser application, reseeding, and silage making (contractor, additives, plastic cover) were based on the actual area required for silage and grazing, and on appropriate costs for Slovenia.

Land improvement and buildings were depreciated at 10% per annum and machinery at 20%, using the reducing balance method (O'Mahony, 1992). Book values used at the start of January for buildings and static machinery were those for the 6th and 7th year since building/purchase, respectively. A 15 year bank term loan was used to fund the cost of the improvement of land and buildings. The interest rate was fixed at 10% per annum, while the loan was currently in its 7th year. The interest portion of the repayment was considered an expense.

Labour requirements were divided between time associated with milking (droving, milking and cleaning), and other farm tasks. Total labour requirement was set at 1848 h per labour unit per year, and costs were typical for Slovenia and assumed to be €1000 per month.

Variable costs (fertiliser, concentrates, replacements, contractor charges, veterinary costs, AI, silage, re-seeding), as well as fixed costs (machinery, buildings, car, electricity, telephone and insurance) were based on the existing prices (Kavčič et al., 2009). Ideally, future prices should be used, but it is difficult to predict prices for future scenarios. Therefore, it was decided to keep current price levels as default values, assuming current prices are likely better predictors of future prices than any past trend. Sensitivity analysis was used to show how future price changes may affect economic values.

The gross milk price was 20.5 ct per kg, based on a reference of 37 g fat/kg milk and 31.5 g protein/kg milk. Hence, milk payment per kilo delivered was based on fat (2.24€ per kg) plus protein (3.93€ per kg) minus costs for transport, milk analyses and costs for cooperative (approximately 150€ per month per farm).

2.3. Trait definition and economic values

Economic values were derived by simulating genetic improvement (δx) for each breeding goal trait independently (i.e., probability of surviving to the next lactation, calving interval, milk, fat, or protein yield and beef daily gain), and comparing the model output with the output from the default scenario. In contrast to the economic model published by Veerkamp et al. (2002), the economic values were now calculated for a zero-profit situation. This indicated that the number of cow-days producing per year was assumed to be fixed. Hitherto, an extended calving interval resulted in a reduced number of cows in the model to make sure that the total number of milking days summed over all cows was the same in the default and changed scenario. When not correcting for a zero-profit situation, you simply produce more milk with an extended calving interval, and hide that this extra milk is produced in a less economic part of the lactation. The change in profit of the farm originates then from a change in costs per animal, corrected for the change in costs due to a change in the number of animals (Groen et al., 1997). In the zero-profit situation a negative profit of the farms is not affecting the economic value, since only the changes in the improved situation versus the default situation are important.

Because the milk quota system, as introduced by the European Union in 1984, will disappear in the near future (2015), economic values were calculated for a non-quota situation. The economic value was given by the marginal revenue minus the marginal cost of increased production.

The economic model was adjusted to be able to calculate the economic value of beef daily gain for the dual purpose breeds Brown Swiss and Simmental. The main assumption was that selection for improved growth does not result in a substantial increase in mature weight of dairy cows, but in a shorter time to reach slaughter weight. Thus the improved margin for weight comes from a shorter feed period. Initially, heavier animals at the same age had a higher intake capacity in the bio-economic model, and therefore with selection for growth, a cheaper ration could be fed (less concentrates). Discussion with the industry suggested that this was an unrealistic effect of selection for growth and, therefore, the assumption was added that genetic selection for growth will result in only minor changes in diet composition, i.e. cows eat more of the same diet.

2.4. Bull rankings

Smith (1983) pointed out that a small change in direction (i.e., change of sign) of an economic value often has a larger effect on ranking of animals than a large change in the same direction. To investigate the effects of the scenarios on bull selection, the August 2009 breeding values for the Slovenian bulls, published in the catalogue of each breed, were gathered and the Spearman rank-correlations (Rs) were calculated between the TMI and the Economic Index (E.I.) based on the defined economic values.

The studied indices used in Slovenia were a TMI for milk for Holstein-Friesian, and two TMIs for Brown Swiss and Simmental: one for milk and one for beef. The economic values were established by a small group of experts and not based on economic calculations. In TMI-milk most emphasis is on the milk production and conformation traits, and obviously in TMI-beef there is more emphasis on beef traits.

2.5. Sensitivity analyses of price changes and of farming system

Assumptions for a series of costs and prices were made for the application of the bio-economic model. To test the

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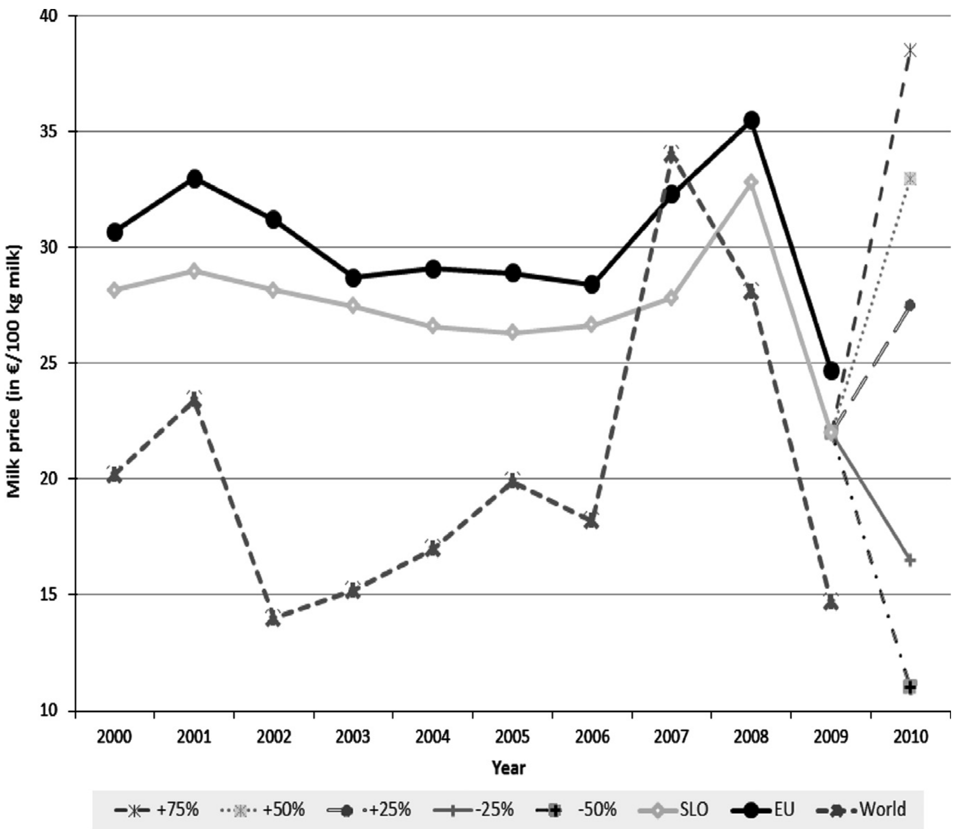

Fig. 1. Milk prices for Slovenia, EU and world since 2000, and five strategies in milk price level (−25%, −50%, +25%, +50% and +75%) for the Slovenian milk prices in 2010 (picture from Klopčič et al. (2010b)).

sensitivity of economic values to these assumptions, several costs and prices were changed; e.g., changes in milk price (+ 75% to −50%), increase/decrease in labour cost (+ or −25%), and changes in beef price (+ or −25%; not for Holstein-Friesians). As shown in Fig. 1, increasing milk prices up to 75% (up to 38.5€/100 kg) were still in the range of historic price levels, while a negative price scenario of −25% (i.e., 16.5€/100 kg) had only been experienced in some periods on the world market of milk. Therefore, changes in milk price of different magnitude in each direction were analysed.

The base farming system in this study was a conventional farm in the flat area of Slovenia. However, several farming systems were compared: organic versus conventional farms, and farms in flat versus hilly/mountainous areas. In general, costs and prices from 2009 were used, taking into account the additional subsidies from government that organic farms and farms in hilly/mountainous areas receive. However, those farm systems usually have higher costs because of more labour intense work compared to conventional farms and/or farms in flat areas.

Moreover, low housing cost farms (1000€ per cow place) were compared with average housing costs of 4000€ per cow place as used as default value in this study, when building a new barn. Also the effect of a higher (doubled in 305d) future milk production level on economic values was evaluated.

Sensitivity of the economic values was investigated by changing one input parameter of the model (price of product or cost of input or farming system or production level or housing costs), and re-calculating the economic values. As a measure of sensitivity, the effect on re-ranking of bulls was examined with the Spearman rank-correlation.

3. Results

3.1. Slovenian farm characteristics

An overview of the simulated herd parameters is given in Table 1 for Holstein-Friesian, Brown Swiss and Simmental farm situations. The number of cows in Holstein-Friesian herds was higher than those in Brown Swiss and Simmental herds, but number of calves was higher in Brown Swiss and Simmental herds, because they were kept for beef production. The land use differed slightly between the Holstein-Friesian, Brown Swiss and Simmental farms, with the largest grazing area available for the Simmental herds.

As expected, the milk production of the specialized Holstein-Friesian cattle was higher than the milk production of the dual purpose Brown Swiss and Simmental. On the other hand, concentrate demand of the dual purpose breeds was much lower than the concentrate demand of Holstein-Friesian cattle, as the former got most of their required energy from roughage.

Average milk, fat and protein yields for Holstein-Friesian cows were 6394, 261.4 and 209.4 kg, respectively, based on a 365 day calving interval and a culling percentage of 25% for the default scenario (Table 2a–c). Average milk, fat and protein yields for Brown Swiss cows were 5055, 211.4 and 172.8 kg, respectively, based on a 365 day

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Table 2a
Key herd parameters in the default situation and when an increase in genetic merit is simulated (only shown where different from default). For milk, fat, protein yield, survival and calving interval (CI) for herds with Holstein-Friesian cattle.

	Default	Milk	Fat	Protein	Survival	CI
Milk per cow (kg)	6394	6458			6401	6407
Fat yield per cow (kg)	261.4		264.0		261.6	261.9
Protein per cow (kg)	209.4			211.5	209.6	209.9
Calving interval (d)	365					366
Proportion cows culled	0.250				0.248	0.251
Milk price (ct/kg)	20.5	20.3	20.6	20.6	20.5	20.5
Hectares used for silage	8.09	8.08	8.05	8.07	8.09	8.08
Total hectares used	6.17	6.15	6.12	6.14	6.17	6.16
# Cows calving	23.9					
Livestock units (LU)	31.25				31.28	31.21
Stocking rate (LU/ha)	5.07	5.08	5.10	5.09	5.07	5.07
Labour units (h)	2205.6	2207.8			2206.5	2205.4
Milk produced (kg)	152,977	154,507			153,133	152,896
Milk sales (kg)	150,600	152,130			150,757	150,525
Fat sales (kg)	6156	6157	6218		6162	6153
Protein sales (kg)	4931	4932		4981	4937	4930
Milk returns (€)	30,866	30,859	31,003	31,059	30,899	30,853
Livestock sales (€)	18,838				18,813	18,798
Total costs (€)	76,401	76,455	76,504	76,450	76,360	76,371
Total profit per farm (€)	−26,697	−26,757	−26,662	−26,552	−26,647	−26,721
Margin per cow (€)	−1116	−1118	−1114	−1110	−1114	−1120
Margin per kg milk (ct)	−17.45	−17.32	−17.43	−17.36	−17.40	−17.48
Feed costs per kg milk (ct)	14.73	14.61	14.80	14.77	14.73	14.73

Table 2b
Key herd parameters in the default situation and when an increase in genetic merit is simulated (only shown where different from default). For milk, fat, protein yield, survival, calving interval (CI), and beef daily gain for herds with Brown Swiss cattle.

	Default	Milk	Fat	Protein	Survival	CI	Gain
Milk per cow (kg)	5055	5106			5059	5066	
Fat yield per cow (kg)	211.4		213.5		211.6	211.9	
Protein per cow (kg)	172.8			174.5	172.9	173.2	
Calving interval (d)	365					366	
Proportion cows culled	0.198				0.196	0.198	
Milk price (ct/kg)	20.6	20.4	20.7	20.7	20.6	20.6	20.6
Hectares used for silage	9.44	9.45	9.46	9.45	9.45	9.43	9.45
Total hectares used	7.65	7.66	7.67	7.66	7.66	7.64	7.66
# Cows calving	16.2						
Livestock units (LU)	24.89				24.90	24.86	
Stocking rate (LU/ha)	3.25	3.25	3.25	3.25	3.25	3.25	3.25
Labour units (h)	2226.8	2228.3		2226.8	2227.3	2226.7	
Milk produced (kg)	81,964	82,783		81,964	82,026	81,926	
Milk sales (kg)	78,959	79,779		78,959	79,022	78,929	
Fat sales (kg)	3302	3304	3335	3302	3305	3301	
Protein sales (kg)	2699	2700		2726	2701	2698	
Milk returns (€)	16,236	16,237	16,310	16,342	16,250	16,230	
Livestock sales (€)	16,331				16,315	16,294	16,353
Total costs (€)	62,076	62,096	62,101	62,087	62,051	62,049	62,083
Total profit per farm (€)	−29,512	−29,532	−29,464	−29,418	−29,489	−29,528	−29,499
Margin per cow (€)	−1820	−1821	−1817	−1814	−1819	−1826	−1819
Margin per kg milk (ct)	−36.01	−35.67	−35.95	−35.89	−35.95	−36.04	−35.99
Feed costs per kg milk (ct)	17.37	17.20	17.39	17.38	17.36	17.35	17.37

calving interval and a culling percentage of 19.8%. Average milk, fat and protein yields for Simmental cows were 4700, 197.8 and 158.4 kg, respectively, based on a 365 day calving interval and a culling percentage of 19.6%. For the Holstein-Friesian population, a herd with 23.9 cows produced 152,977 kg of milk of which 150,600 kg, containing 6156 kg of fat and 4931 kg of protein, was sold, while the remaining 2377 kg of milk was fed to the calves. The dual purpose breeds were kept in smaller herds, produced less milk with lower milk solid contents,

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Table 2c
Key herd parameters in the default situation and when an increase in genetic merit is simulated (only shown where different from default). For milk, fat, protein yield, survival, calving interval (CI) and beef daily gain for herds with Simmental cattle.

	Default	Milk	Fat	Protein	Survival	CI	Gain
Milk per cow (kg)	4700	4747			4704	4710	
Fat yield per cow (kg)	197.8		199.8		197.9	198.2	
Protein per cow (kg)	158.4			160.0	158.5	158.8	
Calving interval (d)	365					366	
Proportion cows culled	0.196				0.195	0.197	
Milk price (ct/kg)	20.6	20.4	20.7	20.7	20.6	20.6	20.6
Hectares used for silage	13.16	13.17	13.18	13.17	13.17	13.15	13.17
Total hectares used	10.49	10.49	10.51	10.50	10.49	10.48	10.50
# Cows calving	19.6						
Livestock units (LU)	31.8				31.8	31.7	
Stocking rate (LU/ha)	3.03	3.03	3.02	3.03	3.03	3.03	3.03
Labour units (h)	2334.4	2336.2			2335.0	2334.3	
Milk produced (kg)	92,212	93,134			92,283	92,168	
Milk sales (kg)	88,418	89,340			88,489	88,383	
Fat sales (kg)	3720	3722	3758		3723	3719	
Protein sales (kg)	2980	2981		3009	2982	2979	
Milk returns (€)	18,205	18,206	18,288	18,322	18,220	18,199	
Livestock sales (€)	22,563				22,543	22,511	22,599
Total costs (€)	69,122	69,144	69,149	69,134	69,091	69,084	69,128
Total profit per farm (€)	−28,333	−28,353	−28,276	−28,228	−28,307	−28,352	−28,303
Margin per cow (€)	−1444	−1445	−1441	−1439	−1443	−1449	−1443
Margin per kg milk (ct)	−30.73	−30.44	−30.66	−30.61	−30.67	−30.76	−30.69
Feed costs per kg milk (ct)	19.27	19.08	19.29	19.28	19.26	19.25	19.27

and more milk was fed to the calves. For the Brown Swiss population, a herd with 16.2 cows produced 81,964 kg of milk of which 78,959 kg, containing 3202 kg of fat and 2699 kg of protein, was sold, while the remaining 3005 kg of milk was fed to the calves.

3.2. Economic values

For Holstein-Friesians, increasing milk yield by 1%, while maintaining the same level of fat and protein yield (Table 2a–c), resulted in slightly lower milk returns, as payment is based on fat and protein yield. Therefore, an increase in milk yield alone, tended to reduce overall profit. This was somewhat exaggerated because there were higher feed costs associated with lactose yield, which increased in direct proportion to milk yield, while lactose had no economic value in the model. Increasing the genetic merit for fat or protein yield by 1%, while maintaining milk yield at default level, increased the margin per cow by €2.00 and €6.00, respectively, while the margin per kg milk increased by 0.02€ and 0.09€, respectively. The greater benefit due to an increase in the genetic merit for protein was a result of the higher protein to fat price ratio, and the higher feed costs for fat (extra concentrates, land, fertiliser and silage making). For Brown Swiss and Simmental, the milk returns were almost identical when the milk yield was increased by 1% through genetic improvement.

Reducing culling percentage from 25% to 24.9% resulted in an increased margin per Holstein-Friesian cow of €2.00. Reduced culling resulted in an increased number of cows finishing their lactation, and changes in replacements costs have been included by requiring fewer replacements per year with longer survival. The increased milk returns (€33.00 per herd) were however, diminished by the reduced income from livestock sales (−€25.00 per herd) plus the higher labour costs (−€6.00). For both the Brown Swiss and Simmental herds, the increase in milk returns was less than the reduction in income from livestock sales, resulting in decreased margins per cow (Table 2a–c).

Increasing calving interval by one day resulted in a reduced margin of €4.00 per Holstein-Friesian cow, of €6.00 per Brown Swiss cow and of €5.00 per Simmental cow (Table 2a–c). The lower margin per cow came from lower livestock sales per cow calving and lower milk returns. Livestock sales dropped although the culling level was kept at default levels, because a shift towards culling at the end of the lactation was associated with less favourable livestock prices.

Improving the beef daily gain over a 6 month period by 5 g/day (i.e., 1 kg heavier over a 6 month period) resulted in a slightly increased margin of €1.00 for both Brown Swiss and Simmental cows. The higher margin per cow came from the increased weight, which has a value that was more than the costs associated with the increased intake, requiring a larger silage area and more concentrates.

Changing one trait by one unit results in absolute economic values. The absolute economic values derived with the bio-economic farm model are shown for the Holstein-Friesian, Brown Swiss and Simmental breeds in Table 3. Based on these absolute economic values and the genetic standard deviation of each trait, the weight in the index was determined (Table 3). This results in a high weight on protein yield in the index of all breeds. For the Holstein-Friesian breed a relatively high value was calculated for milk yield, whereas for the dual-purpose breeds a relatively high value was calculated for beef daily gain.

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Table 3
Economic values (in € per unit and in € per genetic standard deviation) for milk, fat and protein yield (in kg), survival (in %), calving interval (in d) and beef daily gain (in gram/day) for Holstein-Friesian, Brown Swiss and Simmental cattle separate.

	Milk (kg)	Fat (kg)	Protein (kg)	Survival (%)	CIV (d)	Gain (g/d)
	€ Per unit					
Holstein Friesian	−0.04	0.55	2.89	9.55	−0.99	[a]
Brown Swiss	−0.02	1.42	3.37	8.05	−0.98	0.14
Simmental	−0.02	1.45	3.38	7.37	−0.99	0.32
	€ Per genetic standard deviation					
Holstein Friesian	−0.47	0.28	1.00	0.39	0.33	[a]
Brown Swiss	−0.22	0.61	1.00	0.35	0.36	0.19
Simmental	−0.23	0.61	1.00	0.22	0.28	0.49

[a] The economic value for beef daily gain is only determined for the dual purpose breeds.

Table 4
Sensitivity of economic values for milk, fat and protein yield (in kg), survival (in %), calving interval (in d) and beef daily gain[a] (in gram/day) to several assumptions in the default model of for Holstein-Friesian, Brown Swiss and Simmental cattle separate.

	Default	Milk +25%	Milk −25%	Labour +25%	305 d milk x2	Cow place 1000€	Organic	Hilly	Beef +25%
	Holstein-Friesian								
Milk (€/kg)	−0.04	−0.04	−0.04	−0.04	−0.04	−0.04	−0.04	−0.04	[a]
Fat (€/kg)	0.55	1.11	−0.01	0.55	0.56	0.55	0.68	0.50	[a]
Protein (€/kg)	2.89	3.87	1.92	2.89	2.91	2.89	2.95	2.86	[a]
Survival (€/%)	9.55	11.22	7.88	9.29	10.94	9.55	8.99	9.33	[a]
Calving interval (€/d)	−0.99	−1.14	−0.85	−0.98	−1.20	−1.39	−0.92	−0.98	[a]
	Brown Swiss								
Milk (€/kg)	−0.02	−0.02	−0.03	−0.03	−0.03	−0.02	−0.02	−0.02	−0.02
Fat (€/kg)	1.42	1.97	0.88	1.42	1.46	1.42	1.53	1.46	1.42
Protein (€/kg)	3.37	4.32	2.42	3.37	3.44	3.37	3.43	3.39	3.37
Survival (€/%)	8.05	9.31	6.78	7.77	11.34	8.05	8.38	8.16	8.05
Calving interval (€/d)	−0.98	−1.07	−0.89	−0.97	−1.31	−1.39	−1.10	−1.02	−1.13
Daily gain (€/gr/d)	0.14	0.14	0.14	0.14	0.14	0.14	0.16	0.14	0.19
	Simmental								
Milk (€/kg)	−0.02	-0.02	−0.02	−0.02	−0.03	−0.02	−0.02	−0.02	−0.02
Fat (€/kg)	1.45	1.99	0.91	1.45	1.50	1.45	1.57	1.52	1.45
Protein (€/kg)	3.37	4.32	2.43	3.38	3.46	3.38	3.44	3.42	3.38
Survival (€/%)	7.31	8.54	6.20	7.10	10.49	7.37	7.76	7.61	7.37
Calving interval (€/d)	−0.99	−1.06	−0.91	−0.97	−1.23	−1.40	−1.12	−1.07	−1.25
Daily gain (€/gr/d)	0.32	0.32	0.32	0.32	0.32	0.32	0.34	0.33	0.41

[a] The economic value for beef daily gain is only determined for the dual purpose breeds.

3.3. *Sensitivity of economic values*

Sensitivity of economic values to changes in marketing and production circumstances was investigated by re-calculating economic values for a number of different conditions. Economic values were dependent on the prices and assumptions in the default situation. Table 4 shows the sensitivity of the economic values to changes in several assumptions in the default model. Increasing milk volume by increasing yields per cow had little effect on the economic values for milk and milk contents for all breeds. However, the economic value for calving interval was reduced at the higher milk yield level, while the importance of survival increased.

When comparing the farming systems low-cost vs. high-cost per cow-place, and flat areas vs. hilly/mountain areas, the calculated economic values differed only slightly (Table 4). However, for organic vs. conventional farms, the calculated economic values differed for all traits except milk production.

3.4. *Effect of economic values on ranking progeny tested bulls*

The ranking was compared for all bulls presented in the catalogues of Holstein-Friesian, Brown Swiss and Simmental-sires based on their TMI and their calculated economic index. Clearly, for all breeds, a low correlation between ranking on TMI and ranking on E.I. existed (Rs of 0.39; 0.26 and 0.33 for Holstein Friesian, Brown Swiss and Simmental, respectively), indicating a significant re-ranking of sires. The reason for this is the fact that several traits in the TMI are not affecting farm profit directly, but those traits have a strong weight in the TMI, while the E.I. represents a more economically focussed

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approach to defining selection indices for breeding programs.

With an increase in milk price of +25%, hardly any effect was expected on the ranking of the bulls (Rs > 0.94). However, if the milk price increased by 50% or 75% (some) re-ranking of bulls might be expected, because calculated Rs were < 0.85. Also when the milk price dropped 25%, the bulls might re-rank, since Rs were < 0.90, and even < 0.80 if milk price dropped 50%.

Hardly any effect on the ranking of the bulls of any of the breeds was expected when 305 d milk production level would double (Rs > 0.97) or when the cost per cow-place would reduce to 1000€ (Rs > 0.98) in the (near) future. A farming system in a hilly area versus in a flat area did not have an effect on the ranking of the bulls at all (Rs = 1.00). However, for organic farms with Brown Swiss or Simmental cattle one might want to think of a different list of bulls than for a conventional system (Rs of 0.89 and 0.74, respectively). For Holstein-Friesian, the bulls did not rank differently in the conventional and organic farming systems (Rs = 0.99).

4. Discussion

A major goal of most dairy farmers is to maximise profitability, consistent with the health and welfare of cows. For this reason, this study calculated economic values for a revised TMI. It is evident that selection for milk yield alone in dairy cattle will lead to a decline in fertility (Pryce et al., 2004). However, by combining both production and functional traits in one index, it is possible to achieve genetic progress in all traits.

4.1. Absolute economic values

Absolute economic values were derived for milk, fat, protein, calving interval and survival, and presumed to reflect the long-term interest of the majority of the milk producers. Comparing the economic values proved relatively difficult as across studies these are at a different scale en few studies present the economic values per genetic standard deviation. Cottle and Coffey (2013) reported similar economic values for the yield traits, with a negative economic value for milk, and protein being twice as valuable as fat. The absolute economic value for a 1 day increase in calving interval was for all breeds approximately −1€. The financial effect came from lower livestock sales per cow calving and lower milk returns (Cottle and Coffey, 2013).

4.2. Sensitivity analyses

The E.I. is dependent on the input of prices and costs, which fluctuate strongly. Moreover, selection in animal breeding should be in principle based on future prices, which complicates the choice of prices even more. Therefore, the question is how sensitive the results are towards price changes?

The milk prices used in this study covered an overview of EU and world prices over a period of time. Because of differences in calculated economic values with these changing prices, a re-ranking of sires did occur. This shows the importance for the sector and herd improvement organisations to make a good assumption of the future milk price, and calculate the economic values for the selection index based on that assumed milk price.

Most farming systems did not affect the economic values, so the ranking of the bulls would be the same for these farming systems. However on organic farms there were a few changes, and this might have an impact on the bulls whose daughters perform best under organic farming circumstances. Also Nauta et al. (2009) argued that the organic farming system may require its own index. In contrast to many other countries the milk price for organic and conventional milk was the same in Slovenia, resulting in only a slightly higher return from organic milk because of additional subsidies. Cottle and Coffey (2013) also concluded that the majority of the top 10 bulls were high up the rank in all indexes they analysed, but that the little differences may be particularly important for specific herds (e.g., organic herds) for which the chosen bulls are especially good or bad.

Kuipers and Shook (1980) compared net returns from index selection of nine milk plus component testing plans under three milk price schemes. Results were robust towards, for instance, changes in feed prices and discount rate. Although total returns did increase for all plans in a disproportionate way, the plans did rank the same after many years of genetic selection.

4.3. Beef daily gain

Individual feed costs, as well as husbandry and marketing costs, and beef returns were altered by up to 50% from base values (Koots and Gibson, 1998). An increase in milk price of +25% has hardly any effect on the ranking of the bulls, which has been confirmed by other studies. Phocas et al. (1998) have also shown that a small change (25%) in beef price had no significant effect on the relative economic values. The economic value for beef daily gain appeared to be sensitive to the assumption whether or not intake capacity was directly affected by the live weight change. High economic values of 58 ct and 76 ct were calculated for Brown Swiss and Simmental, respectively, when the intake capacity was indeed directly affected by the live weight change, accepting that heavier animals have higher intake capacity and can therefore eat more roughage, which is a cheap diet, resulting in low costs for high revenues (AFRC, 1993). However, even though the biological equations fitted perfectly, the modelled scenario was not realistic, since the extra gain of animals due to selection led to a too strong increase in intake capacity; i.e., capacity increased faster than was needed to fulfil requirements. If the other extreme was assumed (i.e., intake capacity became not larger with increasing selection for growth), then the animal cannot fulfil requirements by eating more roughage, and will require a higher proportion of concentrates (i.e., expensive food) to fulfil the energy requirements. In a scenario with these assumptions, the calculated economic values were much lower; i.e., −16 ct and 6 ct for Brown Swiss and Simmental, respectively. This demonstrated that the economic value

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of beef daily gain was highly sensitive to the underlying assumptions regarding the relationship between selection on increased live weight and intake capacity. In growing beef cattle, Koch et al. (1963) also recognised that differences in both weight maintained and weight gain affected feed requirements. Other studies calculated the feed nutrient requirement using the prediction equation of Fox et al. (1988), with possible adjustment factors for breed differences in mature size (Amer et al., 1992; Amer et al., 1994). None of these studies indicate optimisations of the diet towards higher intake of cheaper feed. Therefore, also in this study we assumed that the increase in live weight establishes that the animal can eat more of the existing diet, and therefore, the diet composition was not re-optimised. This resulted in calculated economic values of 5 ct and 28 ct for Brown Swiss and Simmental, respectively. As always, the truth is probably in the middle, and therefore, based on discussions with the industry, we took into account both a marginal increase in mature weight of dairy cows and minor changes in diet composition. This approach avoided overestimation of the economic values.

4.4. Implications

The three Breeding Associations discussed the outcomes of this study extensively at several stages of the process. The presented economic values are now used in a so called economic index to select Holstein-Friesian bulls in Slovenia. Total merit indices for the dual purpose breeds (Brown Swiss and Simmental) have been adjusted in line with the outcome of this study. This has led to more emphasis on economically important traits in dairy and dual purpose cattle in this country. Inclusion of cell count into the bio-economic model to calculate economic values for the selection index is a goal for the future.

It is important to update the economic values every few years according to the actual and expected prices, especially for those prices that affect the ranking of the bulls; i.e., milk price and beef price.

5. Conclusions

Economic values for milk, protein and fat yield (kg), survival (%), calving interval (d) and beef daily gain (gr/d) were calculated by changing one of these traits whilst keeping the other traits at the default level. Herd parameters (e.g. number of milking cows, replacements, young stock and calving pattern), milk production level, energy requirements, feeding ration, land use and labour requirements were re-adjusted to calculate economic performance. The constructed economic indices, using a farm economic model (Moorepark Dairy Systems Model), ranked bulls in a significantly different manner than how the studied Slovenian Total Merit Indices rank the bulls. The economic values for beef growth (in daily gain) were dependant on the feed intake scenario. In this study the ration composition was assumed to stay the same to meet the additional nutrient requirement. The economic indices were robust towards changes in prices and farming system. Economic values and ranking of bulls showed the highest sensitivity to changes in milk price. Also an organic farming system may perhaps require somewhat different bulls.

Conflict of interest

There are no conflicts of interest (financial, personal or other relationships with people/organisations) that could inappropriately have influenced our work.

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