Total Merit Index (NBDI) for beef sires used for dairy cattle

Economic value of beef sire traits

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Introduction and the method used

The first 10 pages deals with the results obtained in this project. On page 11 there is an extra page with preliminary results for Young Stock Survival. On page 12 and onward there is an appendix with the most important biological and economic assumptions.

The program used for the calculations was the TMI-model for estimation of economic values of the NTM traits in dairy cattle. The input for this model is a set of economic and biological assumptions. Besides, several management scenarios with different culling rates and different use of sexed semen and beef sires can be tested (See the description of the dairy-model in: ”Review of Nordic Total Merit Index, Full Report, November 2018”)

For the calculation of economic value of improving beef cattle traits the standard scenario is used. The standard scenario is a conventional herd with a culling rate of 32%, 50% of replacement heifers born by sexed semen and 70-75% of the older cows inseminated with beef sires.

For this purpose, the dairy version of the TMI-model is modified such that:

- The traits of the purebred dairy animal always remain unchanged
- Growth rate and EUROP form score of beef sires are improved – and the effect in the dairy herds is analyzed
- Survival rate and calving ease of beef sires are improved – and the effect in the dairy herds are analyzed (effect as trait of the calves)
- EUROP fat score is introduced. The reason is that slaughter animals with high fat score are heavily punished in the Swedish and Finnish price system. Therefor improvement of fat score has received much attention in Sweden.
- Besides, the section of the model that describe the effect of improvement of beef traits are calculated separately for purebred and crossbred bull calves and for heifer crosses. That also include the calculation of feed consumption.

The effect on calving difficulty at later calvings for crossbred - on cow mortality have been taken into account. Otherwise, the subsequent effect on the dairy cow giving birth to a beef cross is not considered by this model. Danish analyses have shown that the most important consequence of using beef sire for dairy cows is the increased frequency of difficult calvings.

In the dairy version of the TMI-model the results were expressed per annual cow. If the results in the beef sire version of the TMI-model are expressed per annual cow the values will depend on percent cows used for beef crosses – that again will depend the assumptions on culling rate and the use of sexed semen.

In the beef sire version of the TMI-model it is more reasonable to express the results per crossbred calf. Then the values will be independent of management systems with respect to culling rate, use of sexed semen and percent cows used for beef crosses.

The economic values presented are the effect of improving a trait of the beef sire with one unit. The effect is the value per crossbred calf born.

The TMI-model calculates economic values per dam breed for each NAV country. In the dairy version of the model the results were averaged per breed over countries because it was important to create a common breeding goal per breed across countries.

For beef sires to be used for dairy cows to produce beef crosses for slaughter, we would like to have one set of values across all dam breeds. However, a common NBDI across countries (and dam breeds) is not an ultimate requirement. It is just simpler and more easy to manage in practice.

Economic value of EUROP form score

One important change is that the economic effect of improving form score is calculated separately for purebred and crosses. In the previous versions it was assumed that the effect of improving EUROP form class with one unit would increase beef price with around 0.1 €/kg. Table 1 show the assumptions used in the current version of the model. It is obvious that this change in assumption will change the value of EUROP form score considerably in SWE and DNK. Besides, a larger part of the Danish crossbred bull calves (both bulls and heifers) are slaughtered at low age under the "Danish calf"-concept. That will decrease the value of EUROP form score even more for DNK.

Table 1. Economic effect on value of one kg beef by improving EUROP form class by one unit

	Extra value (€) per kg of beef per unit of EUROP-form			
	SWE	**DNK**	**FIN**	**Based on**
	Very young bulls ("Danish calf"-concept)			
Lin. reg. on form class, purebred	**0.1085**	**0.0607**	**0.0960**	**class 2-6**
Lin. reg. on form class, crosses	**0.0253**	**0.0000**	**0.0611**	**class 5-11**
	Bulls			
Lin. reg. on form class, purebred	**0.1057**	**0.0977**	**0.0829**	**class 2-7**
Lin. reg. on form class, crosses	**0.0337**	**0.0360**	**0.0804**	**class 5-11**

Economic assumption for EUROP fat score

In table 2 it is shown that in DNK there is a deduction in beef price for the lean and a small deduction for the very fat animals. In DNK there is very few fat animals due to the lower age at slaughter. In SWE there is a deduction in beef price for the lean animals and a large deduction for the very fat animals. In FIN there is only deduction for the high fat scores

The non-linear relationships often create problems with the direction of the selection (that is a problem that also exists for some conformation traits).

Table 2. Change in price per kg carcass depending on EUROP fat score

	Deduction in price per kg carcass		
EUROP fat score	**DNK, €/kg**	**SWE, €/kg**	**FIN, €/kg**
1	**-0.27**	**-0.27**	**0.00**
2	**-0.03**	**-0.05**	**0.00**
3	**0.00**	**0.00**	**0.00**
4	**0.00**	**-0.13**	**-0.20**
5	**-0.13**	**-0.67**	**-0.50**

Effect of difficult calvings on cow mortality in subsequent lactation

The effect of difficult calvings have been calculated on Danish data – for 2nd and later lactations and only for cows giving birth to crossbred calves.

Cow mortality is increased by:

- 0.00 percent-point: Easy calving without help
- 1.78 percent-point: Easy calving with some help
- 8.58 percent-point: Difficult calving
- 15.93 percent-point: Difficult calving with veterinarian assistance

These assumptions are used across countries and for all dam breeds. The consequence of improving calving ease are decreased costs of disposal of dead cows but especially higher slaughter value because more cows survive. For first calving and for cows giving birth to purebred calves average cow mortality is used.

Results using basic assumption

In table 3, the main results are shown using the basic assumptions of the beef sire version of NBDI-model. The basic assumption includes:

- Differences in economic assumptions in each country – important is the differences in beef prices and differences in payment systems for EUROP fat score

- Differences in basic biological assumption, e.g. differences in survival rate and calving ease
- Differences in management systems: In SWE and FIN the growth period for bull calves is on average 20 month. In DNK age at slaughter is just below 10 months for half of the calves. For the other half, the age is on average 13 month. This difference has effect on value of EUROP form score and EUROP fat score because the value of these traits has a direct relationship to the carcass weight.

Table 3. Value of improving traits of beef sires used in dairy herds. Value per crossbred calf born in DNK, SWE and FIN. Basic assumptions from the dairy NBDI-model is used.

Country	DNK	DNK	DNK	SWE	SWE	FIN	FIN
Dam breed	JER	RDC	HOL	RDC	HOL	RDC	HOL
Daily carcass gain, € per kg/day	209.9	273.5	271.6	479.2	428.5	286.7	207.2
EUROP form score, € per point	3.0	2.4	1.9	5.4	5.9	11.2	13.1
EUROP fat score, € per point	3.4	4.6	3.7	-15.2	-10.4	-11.0	-9.0
Survival, 1st (0-1)	0	0	0	0	0	0	0
Survival, later (0-1)	156.3	238.4	232.3	359.1	352.1	259.4	249.6
Calving ease, 1st, € per point	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Calving ease, later, € per point	50.84	51.88	57.52	69.33	70.63	35.61	38.77

The results shown in table 3 are the value of improving the breeding value of the beef sire traits with one unit.

- For JER only DNK results are calculated
- For survival and calving ease, the values are zero for 1st calving because one of the assumptions is that no beef crosses are born at 1st calving.
- Within country the differences between RDC and HOL dam breeds are relatively small.
- The value of improving daily carcass gain is highest in SWE because the beef prices are highest in SWE.
- There is difference between the short and long growth period for EUROP fat score and for the EUROP form score, because both traits are expressed on more kilograms of carcass in the long growth period.
  - The value of improving EUROP form is highest in SWE and FIN because the animals are slaughtered at a much higher age and larger carcass weight than in DNK. The weight of the carcass has a direct effect on the value of EUROP form because the slaughter value of each kilogram is higher when EUROP form is improved. In FIN the value is highest because the extra price per unit of form score is highest.
  - For EUROP fat score the carcass weight also has direct effect on the value. The results of the differences in payment for fatness are that the value of higher fat score is negative in SWE and FIN, but slightly positive in DNK.

- For survival at birth the value is highest in SWE, because the revenue by producing a slaughter animal is highest in SWE.
- For calving ease the value is lowest in FIN. It is because the frequency of the very difficult calvings is lowest in FIN and therefore an improvement of calving ease will not change the frequency of very difficult calvings very much (if there is no difficult calvings then an improvement will not change the frequency – it would still be zero)

Value of indexes of beef sires used for dairy cows

Indexes are calculated by dividing estimated breeding values by the standardization factors. These factors are described in the note of Freddy Fikse "Relation between index units and original phenotypes for the BxD evaluation" The results are shown in table 4. They are the "content" of an index unit measured in original evaluation units (kg gain per day, points or frequency survived). From table 3 we know the value of the original evaluation units and therefor we can easily calculate the value of an index unit by multiplication of the results in table 3 with the results in tables 4. The outcome is shown in table 5.

The NBDI (Nordic Beef-Dairy Index) of beef sires can be calculated by multiplying the index by the value per index unit and sum the results across all traits. The results are directly the total the economic value for use on dairy cows. The SD of this sum is value of one standard deviation. Usually we would standardize the NBDI such that SD is 10 NBDI-units. The standardization of NBDI are described by Freddy Fikse in "Implementation details for (sub)indexed in the Beef x dairy evaluation".

A NBDI might be based on a total average of the values in table 3. That would give one NBDI per beef sire – but it will also be a compromise with respect to differences between short and long growth period and the other country differences. Therefor is might be more relevant to consider a NBDI based on:

- Economic values based on the average of DNK values in table 3. That would reflect the DNK production circumstances with respect to growth period (short)
- Economic values based on the average of SWE values in table 3. That would reflect the SWE production circumstances with respect to the long growth period and the higher value of daily gain
- Economic values based on the average of FIN values in table 3. That would reflect the FIN production circumstances with respect to the long growth period and the higher value of EUROP form.
- Economic values for a long growth period based on the average of SWE and FIN economic values in table 3.

- For birth traits (Survival at birth and Calving ease) it was decided to use a common index across the NAV countries based on average economic values from table 3.

Table 4. "Content" of one index unit. Modified results from the note by Freddy Fikse "Relation between index units and original phenotypes for the BxD evaluation"

	Avg all	DNK (short period)	SWE (long period)	FIN (long period)	Avg. SWE+FIN
Daily carcass gain (kg/day)	**0.00117**	**0.00145**	**0.00100**	**0.00105**	**0.00103**
EUROP form score (point)	**0.03367**	**0.03800**	**0.03000**	**0.03300**	**0.03150**
EUROP fat score (point)	**0.01183**	**0.01000**	**0.01000**	**0.01550**	**0.01275**
Calf survival, later (0-1)	**0.00108**	**0.00120**	**0.00105**	**0.00098**	**0.00101**
Calving ease, later (points)	**0.00542**	**0.00613**	**0.00551**	**0.00462**	**0.00507**

Table 5. Relative value per index unit and relative weights based on 4 different alternative NBDIs

	Avg. All	DNK (Short)	SWE (Long)	FIN (Long)	SWE&FIN (Long)
	Economic values/unit (Based on results in table 3)				
Daily carcass gain(kg/day)	**308.1**	**251.7**	**453.8**	**247.0**	**350.4**
EUROP form score (point)	**6.1**	**2.4**	**5.7**	**12.1**	**8.9**
EUROP fat score(point)	**-4.8**	**3.9**	**-12.8**	**-10.0**	**-11.4**
Survival, later (0-1)	**263.9**	**209.0**	**355.6**	**254.5**	**305.0**
Calving ease, later (point)	**53.5**	**53.4**	**70.0**	**37.2**	**53.6**
	Value of one index unit (using the results in table 4)				
Daily carcass gain		**0.365**	**0.454**	**0.259**	**0.359**
EUROP form score		**0.092**	**0.170**	**0.400**	**0.280**
EUROP fat score		**0.039**	**-0.128**	**-0.155**	**-0.145**
Survival, later	**0.284**				
Calving ease, later	**0.290**				
	Relative to value of index for survival at birth				
Daily carcass gain (kg/day)		1.29	1.60	0.91	1.27
EUROP form score		0.32	0.60	1.41	0.99
EUROP fat score		0.14	-0.45	-0.55	-0.51
Survival, later	1.00				
Calving ease, later	1.02				

In table 5 is shown the economic value per index unit - for each of the 4 proposals for a NBDI. The results reflect the conclusions already stated: There is difference between the short and long growth period for the EUROP form score and for EUROP fastness score. For daily gain the value is highest IN SWE due to higher beef prices. For EUROP form score the value is highest in FIN because increased form score results in a higher beef price in FIN (see table 1). For the birth traits it was decided to use a common index across the NAV countries based on average economic values from table 3.

Correlations between alternative NBDI

I table 6 the correlations between the 4 alternative NBDIs. In addition to the NBDIs there are calculated correlations for separate sub-indexes for Growth and Carcass traits and for Birth traits. The correlations are calculated for 246 beef sires of 7 different sire breeds. They have all public indexes for both growth, carcass and birth traits – and they are all born after year 2000.
For birth traits the correlations are all equal to one, because it was decided to use common values across the NAV-countries.

Table 6. Correlations between 4 alternative NBDIs and corresponding sub indexes for growth and carcass traits and for birth traits. Results for 246 beef sires with NBDI - born later than 2002

	DNK	SWE	FIN	SWE&FIN
		NBDI		
DNK	1.000	0.754	0.541	0.645
SWE		1.000	0.914	0.972
FIN			1.000	0.984
SWE&FIN				1.000
		Sub index for growth and carcass traits		
DNK	1.000	0.931	0.777	0.859
SWE		1.000	0.937	0.981
FIN			1.000	0.987
SWE&FIN				1.000
		Sub index for birth traits		
DNK	1.000	1.000	1.000	1.000
SWE		1.000	1.000	1.000
FIN			1.000	1.000
SWE&FIN				1.000
Growth and carcass vs birth traits	-0.565	-0.593	-0.526	-0.565

For Growth and Carcass traits the correlations are lower – and the lowest correlations are found between NBDI based on DNK and on FIN economic values.

The results for the growth and carcass traits are reflected in the results the NBDI. The correlations between the alternative NBDIs are even lower due to the negative correlation between growth and carcass traits on one side and birth traits on the other side.

Consequences for distribution of sire breeds

In table 7 the consequences on breed distribution of selection on some of the alternative NBDIs are shown and compared to the breed distribution among the unselected sires.

In SWE and FIN there is no Hereford(HER) and Angus(AAN) in the selected group when we select the best 100 sires on NBDI whereas many of the Belgian Blue(BBL) are still included. If the NBDI is based on DNK assumptions the best 100 sires are selected nearly equally from all breeds.

If we exclude all BBL sires (leaving 179 sires with NBDI) and select the 75 best sires on SWE or FIN NBDI there is still no Hereford(HER) or Angus(ANG) in the selected group, whereas the share of Blonde d'Aquitaine(BAQ) and Charolais(CHA) increases considerably. In DNK, it is especially Simmental(BSM) and Charolais(CHA) that dominate the selected group when BBL is deleted.

Table 7. Sire breed distribution of the best sires selected by a NBDI on either DNK economic values or average SWE and FIN economic values – besides results for selection on Birth index (246 sires born after year 2000)

			Selected group			
Sire Breed	No	Distri-bution	DNK NBDI	SWE NBDI	FIN NBDI	SWE+FIN NBDI
			Best 100 sires selected			
AAN	24	9.8%	9.0%	0.0%	0.0%	0.0%
BAQ	23	9.3%	9.0%	14.0%	15.0%	14.0%
BBL	67	27.2%	33.0%	54.0%	64.0%	60.0%
BSM	33	13.4%	18.0%	9.0%	0.0%	3.0%
CHA	33	13.4%	17.0%	16.0%	8.0%	13.0%
HER	19	7.7%	3.0%	0.0%	0.0%	0.0%
LIM	47	19.1%	11.0%	7.0%	13.0%	10.0%
			BBL excluded – best 75 sires selected			
AAN	24	13.4%	12.0%	1.3%	0.0%	0.0%
BAQ	23	12.8%	14.7%	22.7%	26.7%	24.0%
BBL	0	0.0%	0.0%	0.0%	0.0%	0.0%
BSM	33	18.4%	26.7%	22.7%	10.7%	16.0%
CHA	33	18.4%	24.0%	32.0%	22.7%	29.3%
HER	19	10.6%	4.0%	0.0%	0.0%	0.0%
LIM	47	26.3%	18.7%	21.3%	40.0%	30.7%

Table 8. Mean, SD, minimum and maximum of indexes per breed. NBDI indexes standardized such the average of all sires are 0 and the SD is 10 units. Results for a (short) NBDI based on DNK assumptions and for a (long) NBDI based on average SWE and FIN assumptions (234 sire born after year 2000)

Breed	No of sires	Mean	SD	Minimum	Maximum
	NBDI based on DNK assumptions (Short growth period)				
AAN	24	-2.3	11.0	-24.0	14.7
BAQ	23	-0.1	11.7	-29.3	18.8
BBL	67	2.5	8.9	-19.7	21.2
BSM	33	1.7	8.5	-19.3	16.1
CHA	33	4.1	8.1	-12.9	19.3
HER	19	-6.3	8.1	-19.1	14.0
LIM	47	-3.8	10.7	-29.1	14.8
	NBDI based on average SWE assumptions (long growth period)				
AAN	24	-11.8	7.0	-22.2	1.1
BAQ	23	3.3	9.0	-18.3	16.0
BBL	67	8.7	6.1	-8.4	21.0
BSM	33	0.0	5.3	-9.9	10.0
CHA	33	2.9	6.1	-10.3	13.2
HER	19	-16.3	4.5	-22.9	-6.0
LIM	47	-3.5	7.0	-18.8	9.7
	NBDI based on average FIN assumptions (long growth period)				
AAN	24	-11.6	5.0	-19.8	-3.3
BAQ	23	4.0	7.7	-14.1	16.5
BBL	67	11.1	5.1	-1.3	22.9
BSM	33	-5.0	3.9	-12.8	2.4
CHA	33	-1.0	5.3	-11.6	10.6
HER	19	-16.7	2.9	-22.5	-9.8
LIM	47	-0.8	5.5	-11.2	13.9
	NBDI based on average SWE+FIN assumptions (long growth period)				
AAN	24	-12.0	5.9	-21.0	-2.0
BAQ	23	3.8	8.3	-16.2	16.6
BBL	67	10.2	5.5	-4.4	22.5
BSM	33	-2.8	4.5	-11.7	5.8
CHA	33	0.7	5.4	-11.3	8.9
HER	19	-16.9	3.5	-23.2	-8.4
LIM	47	-2.0	6.1	-14.3	11.6

In table 8 is shown the mean, SD, minimum and maximum of indexes per breed. NBDI indexes standardized such the average of all sires is 0 and the SD is 10 units. There are results for a NBDI based on DNK assumptions (short growth period) and for a NBDI based on SWE and FIN assumptions (long growth period). The results in table 7 reflects the results in table 6. Under SWE and FIN assumptions, no HER and few AAN sires have NBDIs above 0 among the 246 sires - and BBL sires have the highest average. Under DNK assumptions the CHA sires have the highest average, but there are positive sires within all sire breed groups

Conclusion

From a practical point of view, one common NBDI for beef sires across countries and dam breeds would be preferable. However, the economic value of growth and carcass traits differ between the NAV countries. It is mainly due to differences in age at slaughter and consequently differences in carcass weight, but also differences in price models for EUROP form and fatness have an effect. Therefor the solution might be:

- A NBDI that reflect the value of a short growth period. It is common practice in DNK. The economic value can be determined by DNK assumptions only.
- A NBDI that reflect the value of a long growth period. It is common practice in SWE and FIN. The economic value can be determined by average SWE and FIN assumptions

Economic value of Young Stock Survival (YSS) for beef sires

For beef sire used to dairy sire we want to include all traits of importance. That includes also Young Stock Survival (YSS) – and eventually calf diseases).

Using Danish assumptions, the Young Stock Survival traits have also been analysed for beef sires used for dairy cattle. The results are shown in table 9.

Table 9. Value of improving traits of beef sires used in dairy herds. Value per crossbred calf born in DNK, SWE and FIN. Basic assumptions from the dairy NBDI-model is used.

Country	**DNK**	**DNK**	**DNK**	**SWE**	**SWE**	**FIN**	**FIN**
Dam breed	**JER**	**RDC**	**HOL**	**RDC**	**HOL**	**RDC**	**HOL**
Daily carcass gain, € per kg/day	*209.9*	*273.5*	*271.6*	*479.2*	*428.5*	*286.7*	*207.2*
EUROP form score, € per point	*3.0*	*2.4*	*1.9*	*5.4*	*5.9*	*11.2*	*13.1*
EUROP fat score, € per point	*3.4*	*4.6*	*3.7*	*-15.2*	*-10.4*	*-11.0*	*-9.0*
Survival, 1st (0-1)	*0*	*0*	*0*	*0*	*0*	*0*	*0*
Survival, later (0-1)	*156.3*	*238.4*	*232.3*	*359.1*	*352.1*	*259.4*	*249.6*
Calving ease, 1st, € per point	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*
Calving ease, later, € per point	*50.84*	*51.88*	*57.52*	*69.33*	*70.63*	*35.61*	*38.77*
Young Stock Survival (YSS)							
Survival, 1-30 days (0-1)	**171.6**	**251.6**	**240.4**	**373.8**	**366.7**	**273.0**	**269.1**
Survival, 31-184 days (0-1)	**187.6**	**281.4**	**265.4**	**398.3**	**388.3**	**282.5**	**272.9**

APPENDIX. Tables with basic biological and economic assumptions

Table 1. Average stillbirth (%) for single born calves. (Results for purebred calves have no impact on results in DxB-version of the TMI-model)

	Purebred				**Crossbred**	
Parity	*1st*		*Later*		**Later**	
Sex of calf	*Female*	*Male*	*Female*	*Male*	**Female**	**Male**
RDC-DNK	*3.5*	*5.8*	*1.9*	*3.1*	**2.1**	**2.9**
RDC-SWE	*3.0*	*6.0*	*2.3*	*3.9*	**1.6**	**3.7**
RDC-FIN	*4.9*	*6.4*	*4.0*	*4.9*	**4.1**	**6.0**
HOL – DNK	*5.2*	*9.6*	*2.1*	*4.2*	**2.5**	**6.1**
HOL – SWE	*5.3*	*9.8*	*2.5*	*5.1*	**1.6**	**4.4**
HOL – FIN	*6.9*	*9.4*	*3.0*	*3.8*	**3.2**	**4.3**
JER – DNK	*4.6*	*4.6*	*2.3*	*2.1*	**3.1**	**5.5**

Tabel 2. Frequency(%) of calving ease codes for single born calves. (Results for purebred calves have no impact on results in DxB-version of the TMI-model)

	Easy	**Easy with help**	**Difficult without vet. ass.**	**Difficult with vet. ass.**
	Purebred - 1st parity			
RDC-DNK	84.3	12.5	2.8	0.4
RDC-SWE	90.8	6.7	2.2	0.3
RDC-FIN	65.6	27.2	7.1	0.1
HOL – DNK	74.9	21.6	3.0	0.5
HOL – SWE	88.9	8.3	2.5	0.3
HOL – FIN	63.4	29.3	7.1	0.2
JER – DNK	95.6	3.4	0.7	0.3
	Purebred - later parities			
RDC-DNK	92.6	6.1	0.9	0.4
RDC-SWE	95.1	3.6	1.0	0.3
RDC-FIN	79.7	17.7	2.4	0.2
HOL – DNK	86.8	11.6	1.1	0.5
HOL – SWE	94.9	3.8	0.9	0.4
HOL – FIN	80.4	17.3	2.1	0.2
JER – DNK	97.9	1.5	0.4	0.2
	Crossbred - later parities			
RDC-DNK	**86.8**	**10.5**	**2.2**	**0.5**
RDC-SWE	**90.5**	**7.7**	**1.1**	**0.7**
RDC-FIN	**75.8**	**18.3**	**5.7**	**0.2**
HOL – DNK	**78.1**	**16.9**	**4.1**	**0.9**
HOL – SWE	**89.6**	**6.9**	**2.9**	**0.6**
HOL – FIN	**76.7**	**18.2**	**4.7**	**0.4**
JER – DNK	**86.1**	**9.6**	**3.3**	**1.0**

Table 2. SWE and FIN growth and slaughter quality parameters. (Results for purebred calves have no impact on results in DxB-version of the TMI-model)

Dam breed	Age, days	Live weight, kg	Carcass weight, kg	EUROP Form (1-15)	EUROP Fatness (1-5)
	Purebred bull calves				
RDC - SWE	*598*	*636*	*331*	*5.33*	*2.39*
RDC - FIN	*613*	*650*	*339*	*4.91*	*2.40*
HOL - SWE	*590*	*634*	*327*	*4.37*	*2.21*
HOL - FIN	*590*	*634*	*327*	*4.37*	*2.21*
	Crossbred bull calves				
RDC - SWE	**556**	**631**	**352**	**9.33**	**2.39**
RDC – FIN	**598**	**671**	**378**	**8.91**	**2.40**
HOL - SWE	**551**	**647**	**356**	**8.62**	**2.21**
HOL – FIN	**593**	**692**	**385**	**8.68**	**2.22**
	Crossbred heifer calves				
RDC - SWE	**714**	**568**	**313**	**7.63**	**3.14**
RDC – FIN	**514**	**441**	**242**	**7.63**	**3.14**
HOL - SWE	**703**	**581**	**318**	**7.10**	**2.99**
HOL – FIN	**501**	**451**	**245**	**7.10**	**2.99**

Table 4. DNK growth and slaughter quality parameters. (Results for purebred calves have no impact on results in DxB-version of the TMI-model)

Dam breed	Age, days	Live weight, kg	Carcass weight, kg	EUROP form, (1-15)	EUROP Fatness (1-5)
	DNK Purebred bull calves - Danish calf concept				
RDC	*292*	*403*	*205*	*4.24*	*2.45*
HOL	*292*	*408*	*205*	*3.64*	*2.41*
JER	*-*	*-*	*-*	*-*	*-*
	DNK Purebred bull calves - Short growth period				
RDC	*386*	*459*	*237*	*4.29*	*2.60*
HOL	*357*	*443*	*224*	*3.41*	*2.40*
JER	*462*	*409*	*205*	*3.44*	*2.48*
	DNK Crossbred bull calves - Danish calf concept				
RDC	**290**	**409**	**225**	**7.98**	**2.31**
HOL	**286**	**412**	**225**	**7.53**	**2.30**
JER	**296**	**381**	**204**	**7.04**	**2.34**
	DNK Crossbred bull calves - Short growth period				
RDC	**367**	**491**	**279**	**8.64**	**2.57**
HOL	**361**	**487**	**273**	**8.06**	**2.44**
JER	**376**	**440**	**237**	**6.97**	**2.41**
	DNK Crossbred heifer calves - Danish calf concept				
RDC	**296**	**369**	**205**	**7.45**	**2.84**
HOL	**295**	**371**	**205**	**6.81**	**2.81**
JER	**-**	**-**	**-**	**-**	**-**
	DNK Crossbred heifer calves - Short growth period				
RDC	**402**	**450**	**252**	**7.63**	**3.14**
HOL	**382**	**433**	**239**	**7.10**	**2.99**
JER	**423**	**405**	**213**	**6.30**	**2.98**

Table 5. Beef prices

	DNK (Danish Calf)	DNK (Short)	SWE(long)	FIN(long)
	Base price, EUROP form class 5, €/kg carcass			
Bull calves and crosses	**3.76**	**3.45**	**3.98**	**3.52**
Form class	Addition due to form class (€/kg)			
1	-0.20	-0.49	-0.57	-0.45
2	-0.20	-0.36	-0.57	-0.30
3	-0.20	-0.23	-0.09	-0.18
4	-0.07	-0.09	-0.02	-0.09
5	**0.00**	**0.00**	**0.00**	**0.00**
6	**0.00**	**0.09**	**0.02**	**0.04**
7	**0.00**	**0.11**	**0.09**	**0.13**
8	**0.00**	**0.17**	**0.12**	**0.23**
9	**0.00**	**0.19**	**0.14**	**0.33**
10	**0.00**	**0.21**	**0.19**	**0.39**
11	**0.00**	**0.23**	**0.19**	**0.45**
12	0.00	0.26	0.19	0.50
13	0.00	0.29	0.24	0.55
14	0.00	0.31	0.24	0.60
15	0.00	0.34	0.24	0.63
	Linear regressions used in TMI-program (€/form class)			
Pure: Class 2-7	**0.0607**	**0.0977**	**0.1057**	**0.0829**
Crosses: class 5-11	**0.0000**	**0.0360**	**0.0337**	**0.0804**