NAV Nordisk Avlsværdi Vurdering
Nordic Cattle Genetic Evaluation

Report on Economic Basis for a Nordic Total Merit Index

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Content

Foreword

During the last decade, the cooperation between the Nordic breeding organisations has been steadily more intensive, with some of the landmarks being the establishment of NAV in 2002, publication of the first common breeding values in 2005, and the establishment of the Swedish-Danish AI organisation Viking Genetics from January 2008.

The breeding goal in the NAV countries Sweden, Finland and Denmark has for many years included both production and functional traits. Since the total merit indices in the NAV countries are quite similar, a natural continuation of the increased cooperation was to exploit the possibilities for a common NAV breeding goal.

At the start of 2007, the NAV-board initiated a project on development of a Nordic Total Merit Index. The first and most comprehensive part of the project was to analyse "The economic basis for a Nordic total merit index". The result of this work served as basis for the final evaluation of economic weights to be used in a Nordic Total Merit Index. The results have been presented for AI- and breed organisations at joint Nordic meetings in January and June 2008. Furthermore the results have been discussed at several meetings for farmers in Sweden, Finland and Denmark in the period from January to May 2008.

In August 2008 the NAV board decided to implement a Nordic Total Merit Index, named NTM (Nordic Total Merit). Throughout this report the Total Merit Index is called NAV-TMI in the basis analyses. However the Total Merit Index using the final decided weights is called NTM (Chapter 8).

Important support and information has been supplied by FABA breeding, Svensk Mjølk, Dansk Kvæg and by the research institutions, AI-organisations and breed organizations in Finland, Sweden and Denmark.

Gert Pedersen Aamand
Managing director of NAV
November 2008

1. Introduction

An important step in design of breeding schemes is the definition of a breeding goal. In the breeding goal each trait is assigned a weight expressing the direction and speed of genetic improvement for the trait. The economic value of a trait reflects the contribution of a unit genetic improvement for that trait to the improvement of total efficiency. As the breeding values in the Nordic breeding value estimation are expressed as indices, the economic value has to be transformed to the value per index unit. These will also be presented in the present report.

The breeding goal in the NAV countries Finland, Sweden and Denmark have for many years included both production and functional traits. In fact the Nordic countries have been leading in that area with our "Nordic profile" for more than 25 years, (Pedersen et al., 2002; Juga et al., 1999; Philipsson et al., 1975).

During the last decade, the cooperation between the Nordic breeding organisations has been steadily more intensive, with some of the landmarks being the establishment of NAV in 2002, publication of the first common breeding values in 2005, and the establishment of the Swedish-Danish AI organisation Viking Genetics from January 2008.

Since the total merit indices in the NAV countries are quite similar, a natural continuation of the increased cooperation was to exploit the possibilities for a common NAV breeding goal. Therefore the present project was initiated. The objective of the project was to develop the economic basis for a Nordic total merit index. This includes:

- Assessment and analyses of the economic conditions for milk production in Sweden, Finland and Denmark from a perspective of dairy cattle breeding
- Development of an economic model that can evaluate the economic value of traits of interest
- Estimate and analyze economic values of the traits of interest for the Nordic Holstein breeds, the Nordic Red Dairy Cattle (RDC) and for the Jersey breed. RDC is composed of RDM from Denmark, SRB from Sweden and FAY from Finland.

The result of this work is intended to serve as basis for a final evaluation of economic weights to be used in a Nordic Total Merit Index. This final evaluation will furthermore include breed policies as well as ethical and consumer aspects.

2. Background

Total Merit Indices (TMI) in the Nordic countries are basically quite similar, but the economic weights given to different traits are not identical, and the number of traits included in the TMI are different. It means that the genetic response will be somewhat different using the Finnish, Danish or Swedish TMI as selection criterion.

In table 2.1 and 2.2 the TMI in Denmark, Sweden and Finland are compared. The effects of the different TMI are expressed as a correlation between the different indices and the TMI index for AI bulls born in a 3 year period (1999-2001). The correlations times 100 express the response in percentage of the maximum response given that the trait was the only trait in the breeding goal, when selecting within this group of bulls.

In the Nordic TMI, considerable weight is put on health and reproduction traits. By selecting bulls based on the TMI within each country for RDC, all countries will achieve 32% to 55% of the genetic progress for udder health using these bulls compared to a situation where the bull was selected only for udder health (table 2.2). For comparison, the genetic superiority in yield traits is 52% to 66% of the maximum response. The corresponding figures for Holstein show that all countries will achieve progress for udder health from 39% to 48% (table 2.1) compared to a situation where the bulls were selected only for udder health. The response in yield traits is 42% to 75%.

Table 2.1 Correlation between present national Total Merit Index (TMI) and EBVs for single traits within the **Holstein** breeds.

Trait	Denmark	Finland	Sweden
Yield index	0.53	0.75	0.42
Growth	0.08	-	-0.13
Fertility	0.32	0.00	0.32
Birth index	0.31	0.06	0.44
Calving index	0.37	0.23	0.53
Udder health	0.41	0.48	0.39
Other disease	0.44	0.34	0.23
Body	0.02	0.20	0.08
Feet&Legs	0.14	0.11	0.29
Udder	0.45	0.42	0.35
Longevity	0.49	0.36	0.44
Milk ability	0.21	0.14	0.01
Temperament	0.05	0.10	-0.01

Table 2.2 Correlation between the present national Total Merit Index (TMI) and EBVs for single traits within the **Red Dairy Cattle (RDC).**

Trait	Denmark	Finland	Sweden
Yield index	0.64	0.66	0.52
Growth	-0.02	-	0.21
Fertility	0.08	0.19	0.34
Birth index	0.21	0.00	0.17
Calving index	-0.05	0.15	0.32
Udder health	0.55	0.32	0.38
Other disease	0.43	0.09	0.09
Body	-0.12	0.19	0.12
Feet&Legs	0.02	0.14	0.14
Udder	0.36	0.40	0.34
Longevity	0.61	0.27	0.49
Milk ability	0.31	0.12	0.03
Temperament	0.16	0.11	-0.01

However, these correlations give only quite an inaccurate estimate of the genetic progress to be achieved in a population using the Total Merit Index as selection criterion. The correlations are based on a small sample size (AI bulls born in 1999-2001) sired by quite few sires and eventually selected based on slightly different breeding goals, and therefore the correlations will deviate if some of the bulls are exchanged. Furthermore these correlations overestimate the genetic progress for functional traits, because the correlations between the same indices would be lower if they were based on cow indices. That is because cows have relatively less information on functional traits than yield and type traits compared to progeny tested AI bulls. This will result in lower progress for functional traits in the cow selection path, and higher progress for production traits.

It is well known that the genetic correlations between both yield and fertility and yield and udder health are unfavourable. Still, by selecting for TMI as defined in the Nordic countries, it is possible to get a positive trend for fertility, udder health as well as yield traits. However, there have not been positive genetic trend for all functional traits within the Nordic population (see figure 2.3 to 2.6).

Figure 2.1 and 2.2 show that both within the Holstein populations and within the RDC populations there has been substantial progress for yield – here illustrated by progress for the Yield index.

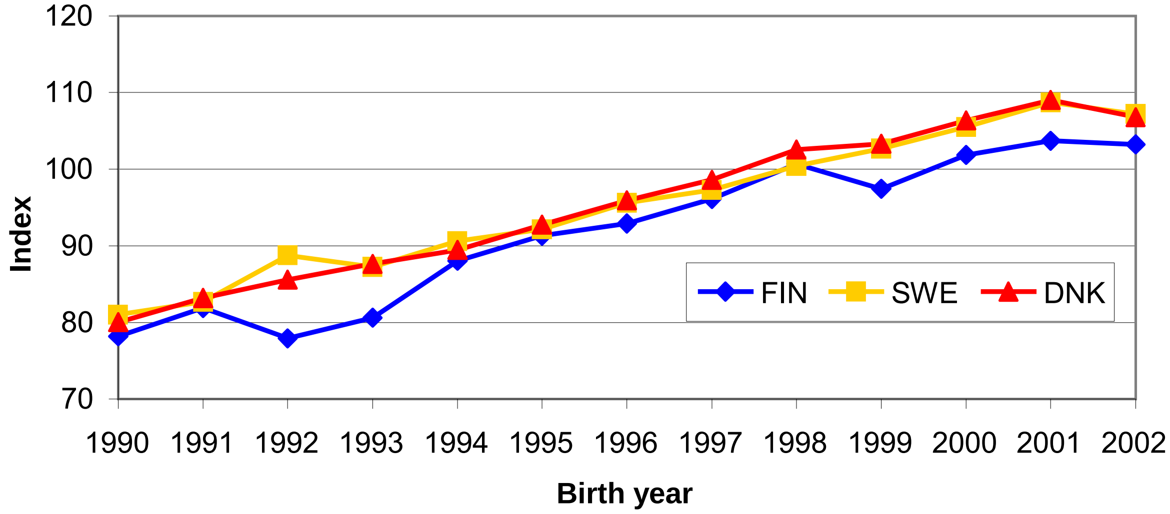

Figure 2.1 Genetic trend for Yield index based on NAV sub-index weights for milk, fat and protein production for Holstein bulls in Sweden, Finland and Denmark.

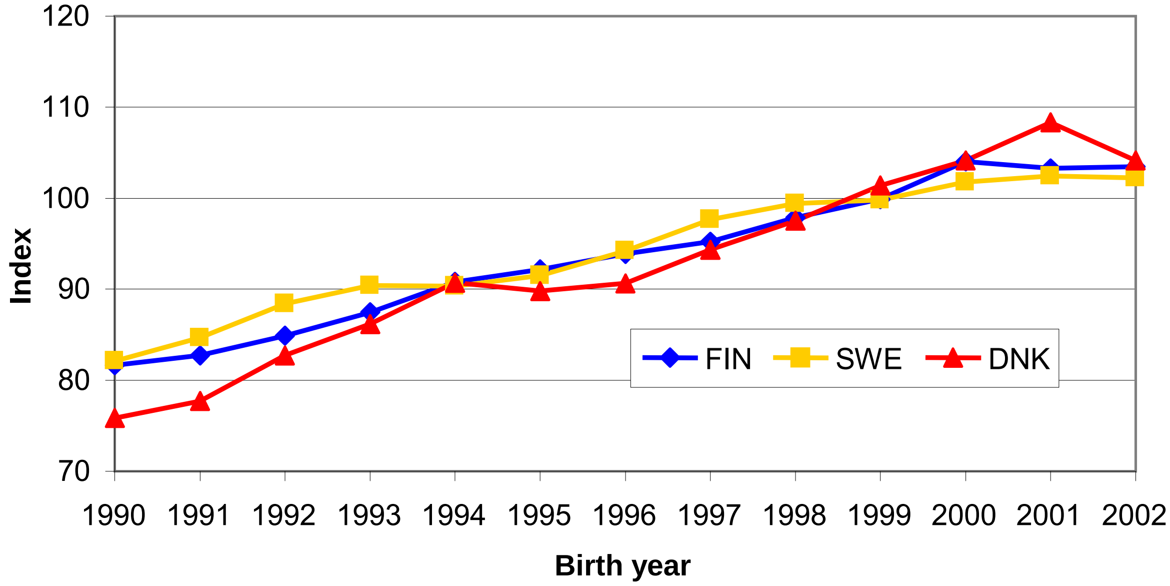

Figure 2.2 Genetic trend for Yield index based on NAV sub-index weights for milk, fat and protein production for RDC bulls in Sweden, Finland and Denmark.

Figure 2.3 shows the genetic trend for fertility for the Holstein populations. There has been a tremendous decline for that trait, corresponding to the decline in other Holstein populations (e.g. Evans et al., 2006; VanRaden et al., 2004). It can also be seen that the Finnish Holstein population is at a higher genetic level for fertility than the Holstein populations in Sweden and Denmark. Presumably the reason is the higher percentage of original black and white genes in the Finnish Holstein population compared to the Danish and Swedish Holstein populations.

The amount of original black and white genes for calves born in 2003 within the three populations were 5.7%, 13.3% and 32.1% for Denmark, Sweden and Finland, respectively. The trend has been more stable for RDC. This is due to a more intensive use of national sires of sons with reliable EBVs for functional traits and a more consequent selection of breeding animals based on TMI.

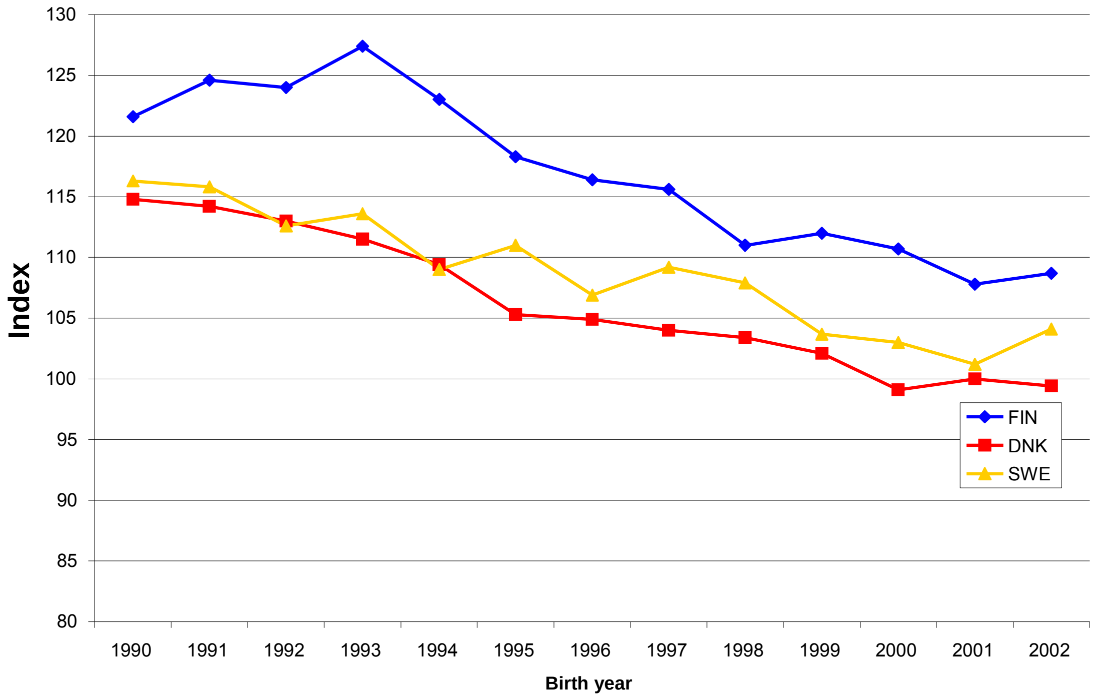

Figure 2.3 Genetic trend for Female fertility for Holstein bulls in Sweden, Finland and Denmark.

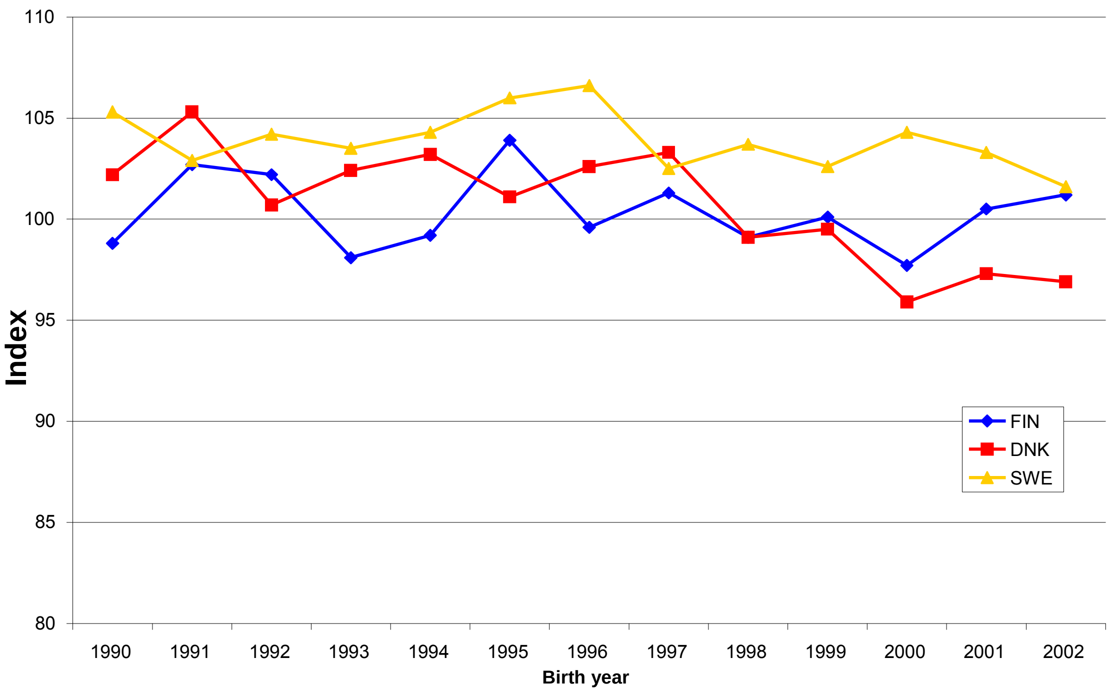

Figure 2.4 Genetic trend for Female fertility for RDC bulls in Sweden, Finland and Denmark.

Figure 2.5 and 2.6 show the genetic trends for udder health. For both populations the trend has been more or less stable during the last 15 years. Within RDC, SRB is at a higher level compared to RDM and FAY.

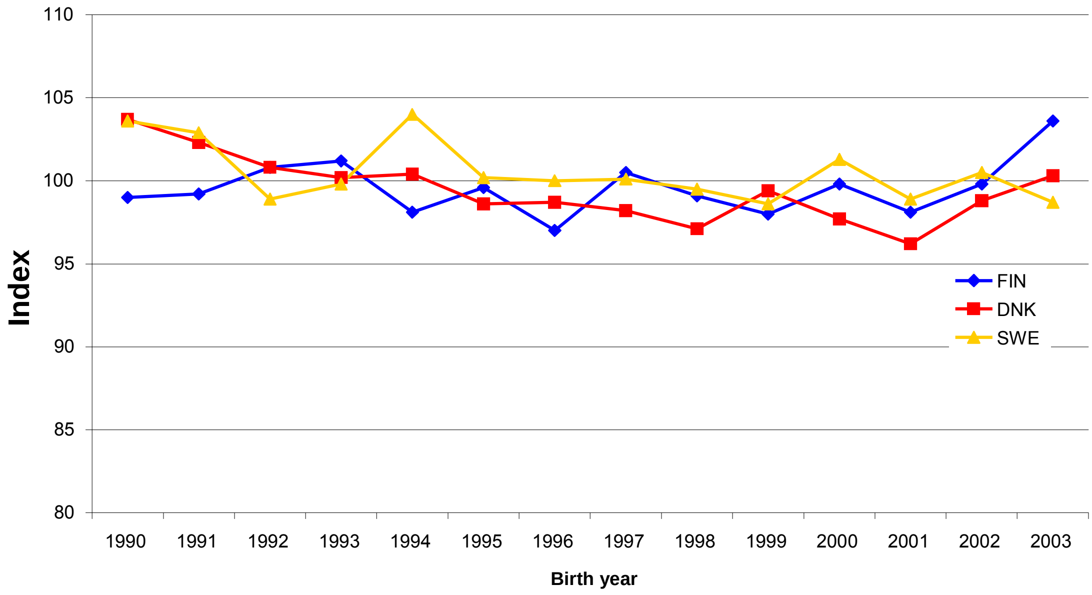

Figure 2.5 Genetic trend for Udder health for Holstein bulls in Sweden, Finland and Denmark.

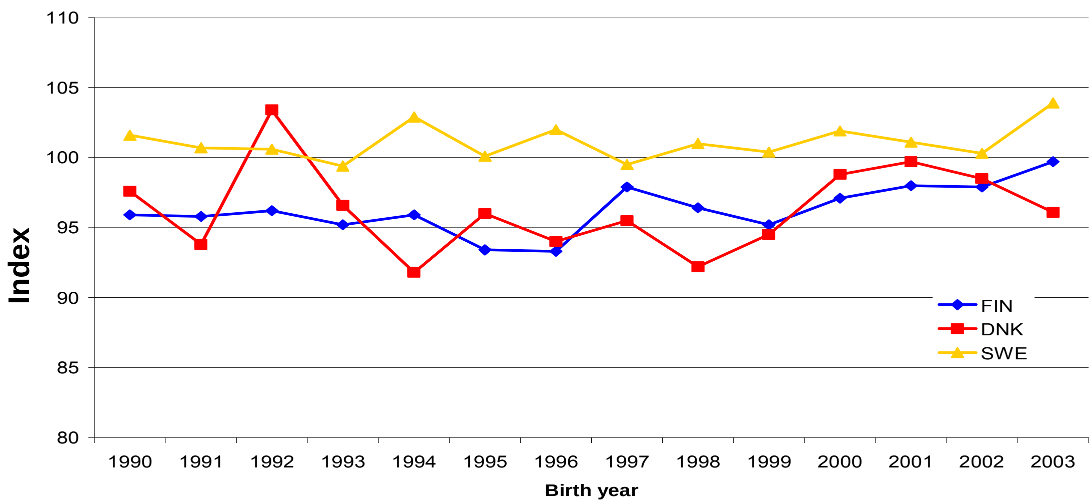

Figure 2.6 Genetic trend for Udder health for RDC bulls in Sweden, Finland and Denmark.

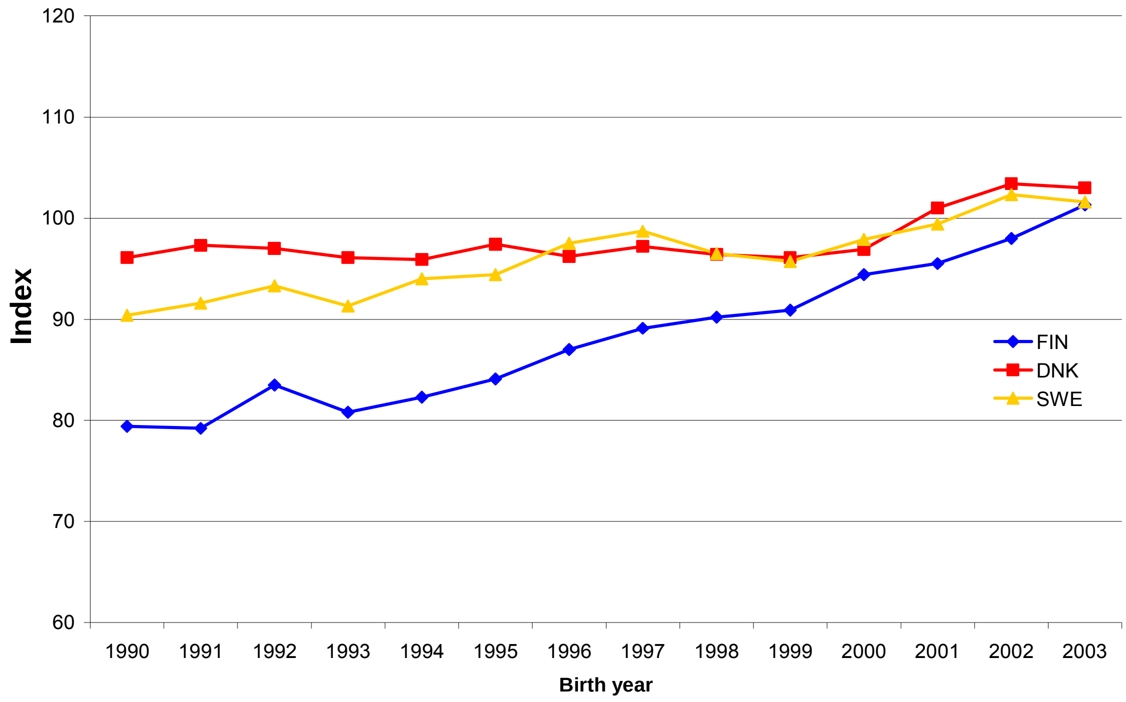

Figure 2.7 Genetic trend for Udder conformation for Holstein bulls in Sweden, Finland and Denmark.

Figure 2.7 and 2.8 show the trends for udder conformation. For the Swedish and the Finnish populations – both Holstein and RDC there has been a significant progress for the trait within this period. Within the Danish populations, the progress has been smaller.

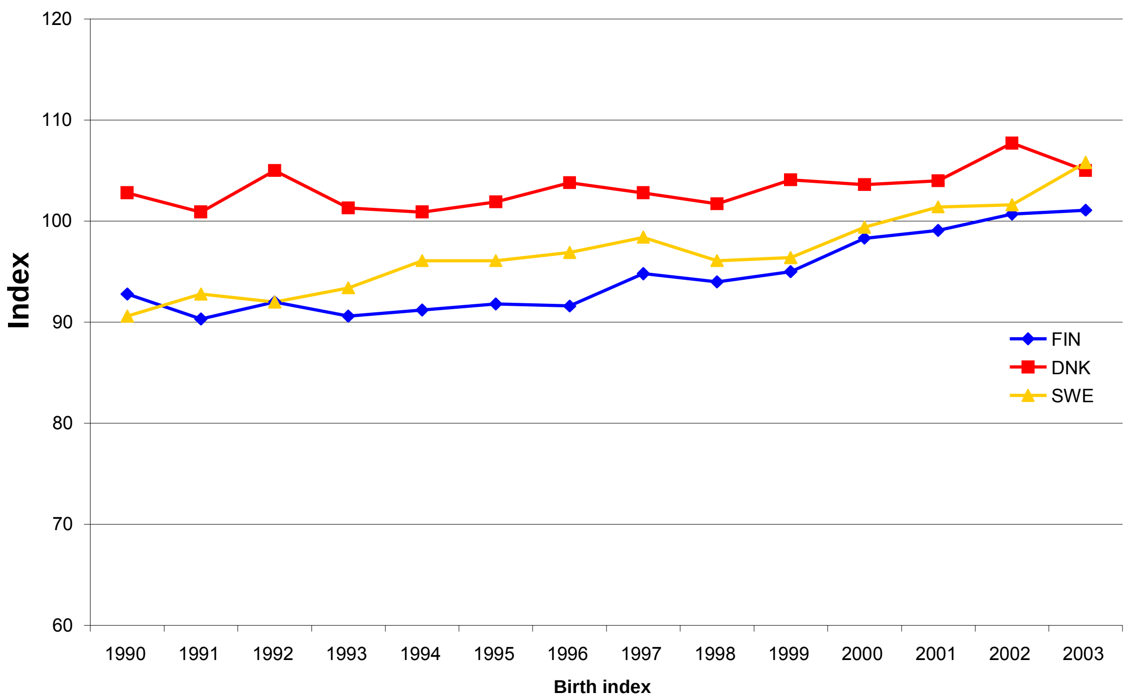

Figure 2.8 Genetic trend for Udder conformation for RDC bulls in Sweden, Finland and Denmark.

For Feet&Legs the genetic level has been stable within the period as shown in figure 2.9 and 2.10.

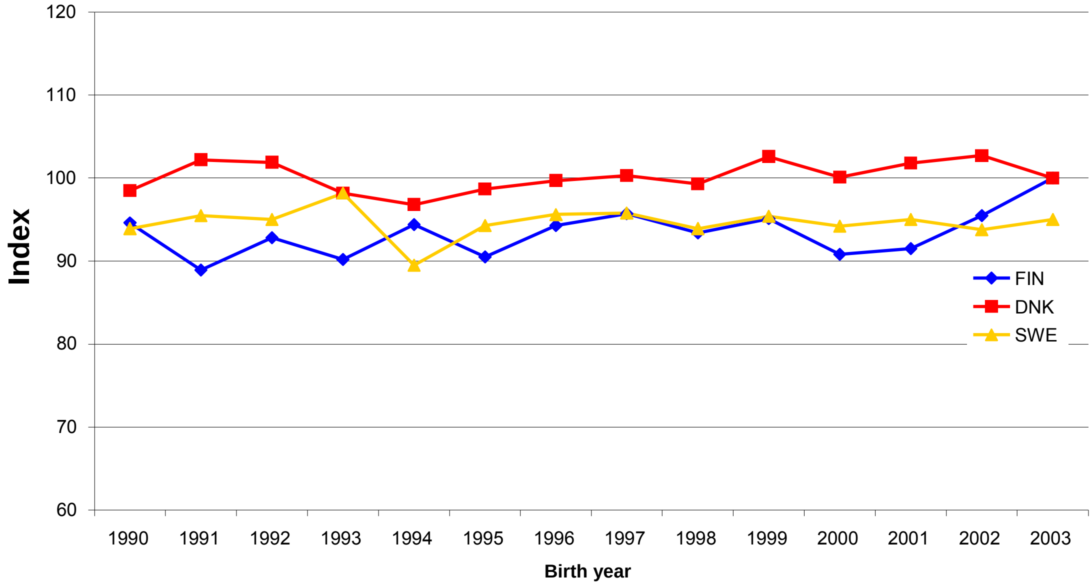

Figure 2.9 Genetic trend for Feet&Legs for Holstein bulls in Sweden, Finland and Denmark.

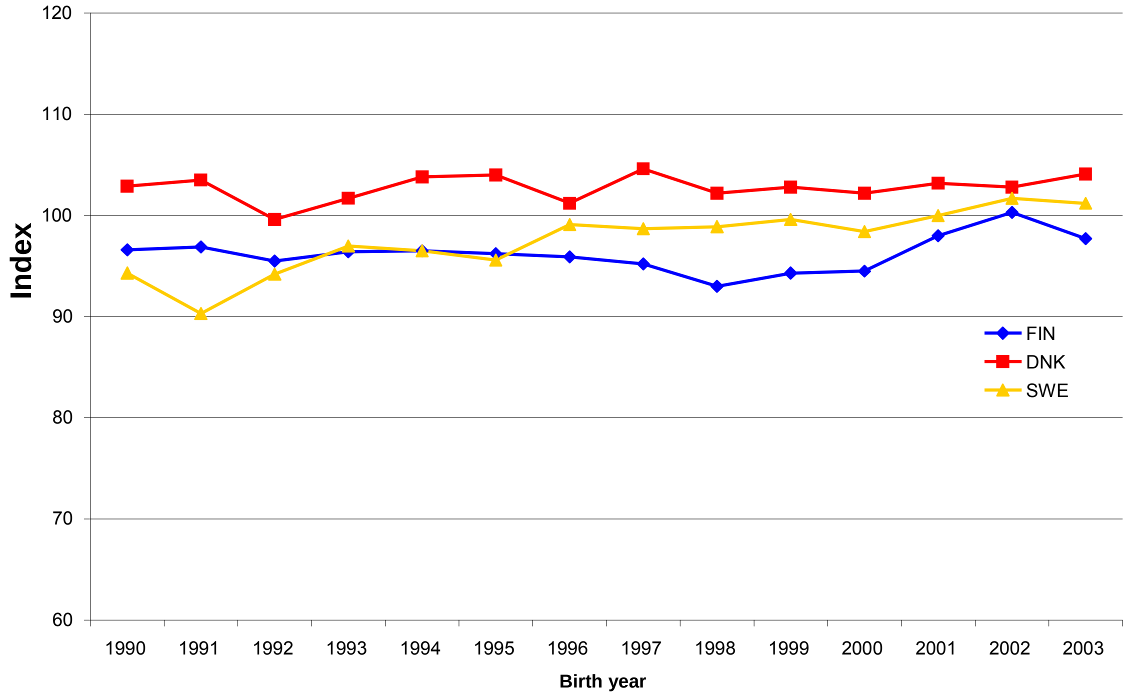

Figure 2.10 Genetic trend for Feet&Legs for RDC bulls in Sweden, Finland and Denmark.

The reason why these trends deviate from the expectations based on the TMI are foremost that TMI in the past was not used consequently in selection of breeding animals, especially in selection of sires of sons and bull dams. The inconsistency related to the use of TMI has been more pronounced within the Holstein populations with importation of sires of sons from populations without information about functional traits. Therefore, the genetic trends for the Holstein populations are in general more negative for functional traits compared to the trends for the RDC populations.

Finally, it must be pointed out that the genetic progress achieved over the last years is a consequence of selection done 5 to 15 years ago. This means that we must compare trends of today with the selection indices (preferable TMI) used 5 -10 years ago when we draw conclusions on the effect of previous selection.

3. General Methods and Assumptions

3.1 Theory

Economic values can be derived by different methods. The two most important methods are: Non-objective and objective methods.

The non-objective methods are subjective assessment of weight, desired gain or restricted gain methods. When using desired gain (or restricted gain) methods, one makes a backward solution so-to-say where the starting point is the requirement for the gain to be obtained for some key traits. Based on these requirements, the economic weights are calculated in such a way that the requirements are fulfilled.

When the objective methods are used for calculation, the economic values are based on simulation (modelling) of the real world and the marginal value of the improvement of each of the breeding goal traits is estimated as illustrated in figure 3.1. The model assumptions can either be based on present or preferably on future production circumstances. Even though the models are objective, it can be argued that the assumptions are not fully objective.

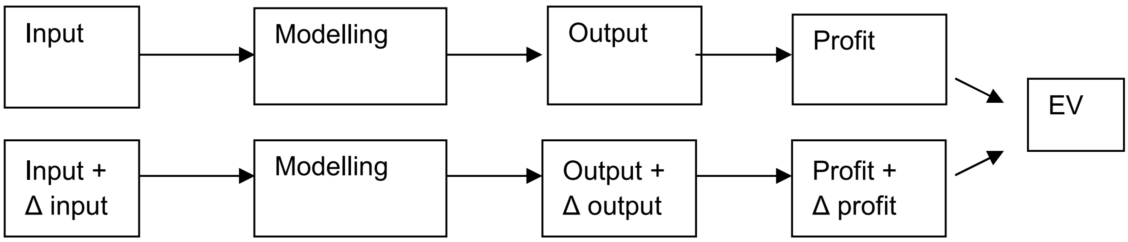

Figure 3.1. Derivation of economic values (EV) using a simulation model and partial budgeting (modified by Nielsen (2004) after Groen, 2001).

The basis for the present calculations is the estimation of the marginal profit for the traits to be included in the breeding goal as described by Brascamp et al., (1985) and Groen et al., (1997). The economic values are marginal economic values, which mean the economic value of one unit improvement of the trait – keeping the remaining traits constant. The value of milk protein is therefore calculated as the economic profit of improving the milk protein yield by one kg, all other traits being constant.

The starting point for the calculations was simple profit calculation – output minus input. More complicated models can normally describe the economic association for a broader spectrum of assumptions and through a longer time horizon. But whether or not the models are simple or complicated they have to fulfil the following basic demands:

- The contribution of a trait to the profit must be well defined
- The contribution of a trait to the profit must be independent of changes in other traits
- The selection decisions made today will have effect 5-15 years ahead. The assumption must reflect this fact
- Since the time horizon in cattle breeding is long all costs must be variable in principle.

Before the model is agreed on, the economic profit goal must be decided, since the profit can be calculated for different units:

- Per herd
- Per animal (year cow) within the breed
- Per AI company
- For the whole dairy industry

- For the society (per citizen)
- Per Euro of sold goods.

Often the profit is calculated per herd but under most circumstances the estimated economic weights are independent of the unit chosen.

Another issue of importance is incorporation of ecological, social and ethical aspects in the breeding goal as pointed out by Groen et al., (1997) and Olesen et al., (2000).

3.2 Present Model Assumptions

The basis for the economic values calculated in the present project is an objective deterministic economic model trying to mimic the economic situation on a dairy farm. It is the same type of model that has been used in a simpler version in the previous Danish calculations of economic values (Pedersen et al., 2003). The calculations are performed in an Excel sheet named TMI. A detailed description of the model is given in appendix A.

The model includes all important factors influencing the total economic output from dairy farming. The assumptions include basic figures on milk and feed prices and prices of other input and output factors, basic phenotypic levels for all traits, and workloads associated to handling of cows e.g. time used for a mastitis treatment or time used for an insemination. All these figures are given for the different breeds and the different production environments within the NAV area.

The breeds considered in the present analyses are Holstein, RDC (RDM, SRB, FAY), and Jersey. The different production environments considered are Denmark (DNK), Sweden (SWE), Finland “South” (FIN S) and Finland “North” (FIN N). Finland is divided in two regions due substantial differences in production circumstances and pricing systems.

3.3 Biological, Economical and Management Assumptions for the Different Traits

3.3.1 Production Traits (milk and beef)

There are differences in the phenotypic level for the different breeds and countries. Within Holstein, these differences are mostly due to different management systems within the different countries, even though there are differences in the amount of Holstein genes within the three populations. The assumptions on yield and beef production are given in table 3.1 and 3.2 respectively. The figures are based on actual national statistics.

Table 3.1 Assumed average phenotypic milk production level for the different breeds, 305 day yield (kg).

	RDM DNK	SRB SWE	FAY FIN	HOL DNK	HOL SWE	HOL FIN	JER DNK
Milk, 1st lact.	7217	7755	7477	7808	8558	7995	5345
Milk, 2nd lact.	7891	8470	8528	8863	9843	9162	6006
Milk, 3rd lact.	8212	8790	8902	9239	10074	9648	6246
Protein, 1st lact.	254	271	258	260	284	268	214
Protein, 2nd lact.	280	296	293	299	326	309	247
Protein, 3rd lact.	289	303	300	308	331	320	255
Fat, 1st lact.	303	335	320	317	337	311	313
Fat, 2nd lact.	333	363	361	361	389	356	355
Fat, 3rd lact.	346	377	377	379	403	378	371

Table 3.2 Assumed phenotypic levels for production of slaughter bulls.

	RDM DNK	SRB SWE	FAY FIN	HOL DNK	HOL SWE	HOL FIN	JER DNK
Age at slaughter (days)	376	592	627	372	594	627	472
Live weight (kg)	469	640	670	457	651	670	412
Carcass weight (kg)	245	313	335	233	319	335	204
Daily gain (kg/day)	1.247	1.081	1.069	1.228	1.096	1.069	0.833
Daily net gain (kg/day)	0.652	0.529	0.523	0.626	0.537	0.523	0.415
EUROP form (point, 1- 15)	4.85	5.06	4.8	3.81	4.21	4.1	3.26

In the project group, the model assumptions have been discussed intensively, because differences in assumptions will of course create more or less different economic values. The most important assumptions are milk and feed prices and the assumed feed utilisation. These figures are important in relation to the balance between the weights given to production traits and functional traits. Increased feed prices (or reduced feed utilisation), shift the balance from production traits towards functional traits.

The assumed economic values are based on the economic situation in the first part of 2007 when the project was initiated. It would have been more optimal to use the economic values which will be valid 5-10 years ahead, since offspring of breeding animals selected today first will exploit their genes 5-10 years ahead, but these are unknown. It has been decided to ignore the actual increased milk and feed prices, since they presumably have not reached a balance yet. The arguments for using 2007 prices are that the relationship between milk and feed prices has been stable within the last 20 years except within the last part of 2007, and there is no foreseen indication that this will change. However, the relationship between output and input prices except feed prices has been changing during the last 20 year in disfavour of output prices. If this trend will continue then the result will be that the economic values estimated for non production traits will tend to be too low compared to production traits.

The most important assumptions are of course milk and feed prices and the assumed feed utilisation. These figures are important in relation to the balance between the weights given to production traits and functional traits. Increased feed prices (or reduced feed utilisation), shifts the balance from production traits towards functional traits. In table 3.3 assumptions on milk and feed prices are given.

Table 3.3 Assumptions on milk, meat and feed prices.

	Units	Sweden	Denmark	Finland "South"	Finland "North"
			Milk		
Milk	€/kg	-0.020	-0.020	0.052	0.330
Fat	€/kg	3.21	3.21	2.40	2.40
Protein	€/kg	5.45	5.45	6.50	6.50
"Standard milk"	€/kg	0.300	0.300	0.374	0.652
			Slaughter animals		
Bull calves	€/kg*	2.70	3.12	2.89	3.53
Young bulls	€/kg*	3.10	2.48	3.21	3.85
Cows	€/kg*	2.30	1.86	1.64	1.64
Heifers	€/kg*	2.90	2.32	3.12	4.05
			Springing heifers		
RCD	€ ap	1160	1160	1220	1220
HOL	€ ap	1160	1160	1350	1350
JER	€ ap	-	720	-	-
			Concentrates		
Grain	€ / kg	0.17	0.17	0.19	0.19
Protein (soya)	€ / kg	0.25	0.23	0.25	0.29
Calf mixture	€ / kg	0.20	0.20	0.22	0.22

* Per kg carcass

In table 3.3 it can be seen that there are some differences in price setting for feed stuff in the different regions. As mentioned above, higher feed prices compared to milk prices generally favour functional traits in the breeding goal compared to yield traits. The value of a unit increase in EUROP class score is assumed to be 0.10 in Denmark, and 0.09 in Sweden and Finland.

Another very important issue related to modelling profit of milk production is the Marginal Feed Utilisation (MFU). The MFU used in the previous Danish breeding goal calculation has been 65% as cited by Østergård & Neimann-Sørensen, (1989) for the last feed kg of feed given to a dairy cow measured either in SFU or mega joule. These figures are based on Danish herd registrations from the period from 1967 up to 1986 on 108 farms. In that period the daily feed intake increased 3.55 SFU, while the daily energy output of the cows increased by 2.29 SFU. Based on these figures the MFU level is calculated at 65% (2.29/3.55). However, the difference, this MFU is based on, is not only due to genetic differences, they are also due to improved management within the herds. Decreased MFU has the same effect as increased feed prices and visa versa.

In the present situation the most interesting MFU is the MFU where yield capacity is increased only due to improved genetic level. This situation is very difficult to measure and very few figures for these MFU exist – the only reference found is Østergård and Neimann-Sørensen, (1989). Based on the quite tight registrations, they calculated the marginal MFU to be 74% due to genetic improvements. Another way of looking at this complex issue is to use Residual Feed Intake (RFI) as described by Veerkamp et al. (1995). RFI is measured as obtained feed intake minus required energy requirements (corrected for feed efficiency). Their conclusion is in agreement with results from Østergård and Neimann-Sørensen (1989), both saying that the

MFU due to genetic improvement is higher than the general MFU, since the correlation between the genetic part of RFI and feed intake is lower than the correlation between total RFI and feed intake. All this leads to an assumption of a MFU at 65% in the present calculations.

3.3.2 Fertility

In table 3.4 and 3.5 the assumptions for fertility traits are given for heifers and cows respectively.

Table 3.4 Assumed average phenotypic fertility levels for heifers within the different breeds.

	RDM DNK	SRB SWE	FAY FIN	HOL DNK	HOL SWE	HOL FIN	JER DNK
Age at 1st AI, days	537	549	487	517	544	492	472
Conception rate, %	67.5	62.5	62.5	58.0	62.5	65.0	58,0
Insemination rate, %	60.0	65.0	67.5	55.0	65.0	67.5	55.0
Interval: 1st - last AI (IFL)	15.3	17.9	17.2	22.2	17.6	15.7	*22.2*
Number of AI (AIS)	1.45	1.57	1.57	1.63	1.56	1.51	1.63
Days pregnant	281	280	279	279	279	279	281

Table 3.5 Assumed average phenotypic fertility levels for cows within the different breeds.

	RDM DNK	SRB SWE	FAY FIN	HOL DNK	HOL SWE	HOL FIN	JER DNK
Calving - 1st AI (ICF), days	76.2	88.0	88.1	81.0	95.1	87.5	75.0
Conception rate, %	49.0	45.0	30.0	30.0	35.0	35.0	41.0
Insemination rate, %	40.0	45.00	37.5	35	40	37.5	35
1st - last AI(IFL), days	29.8	32.4	42.2	41.7	39.2	38.9	34.8
Number of AI (AIS)	1.70	1.82	1.99	1.95	1.95	1.91	1.77
Days pregnant (DP)	282	280	279	281	280	279	282
Calving interval (CI)	388	400	409	403	414	405	392

The input parameters are conception rate (CR) and insemination rate (IR). The two parameters were estimated based on statistics on length of insemination period (IFL) and number of inseminations (AIS) simply by calculating IFL and AIS - in the TMI-model - for all possible combinations of CR and IR. The set of CR and IR where IFL and AIS were closest to the results seen in practice was selected as assumed input parameters.

The interval from calving to first insemination in RDC is at a lower level than that in the Holstein in Denmark and Sweden. In Finland, Holstein and FAY are at the same level. The same pattern can be seen for number of days from first to last AI (IFL) for cows. For heifers, insemination starts at the age given in table 3.4, and for cow's insemination starts 75 up to 95 days after calving depending on breed, as shown in Table 3.5. For both heifers and cows, it is assumed that the insemination period continues until pregnancy or until day 168 (8 insemination periods) after first insemination. Animals, which are still not in calf at day 168, are assumed to have been slaughtered.

The work load related to one AI is set to 0.25 hours as given in table 3.15. The time used for heat detection is set to 42 seconds per animal within the observation period. The figures for heat detection are based on a Danish report on time use in large dairy herds from 2003.

3.3.3 Longevity

The value of longevity is estimated by changes in culling rate. The assumed average culling rates are based on figures calculated from the input dataset for prediction of NAV yield indices. These figures are given in table 3.6.

Table 3.6 Assumed average phenotypic culling rates in the different lactation within the different breeds.

	RDM DNK	SRB SWE	FAY FIN	HOL DNK	HOL SWE	HOL FIN	JER DNK
1st lact.	33 %	34 %	25 %	30 %	31 %	25 %	29 %
2nd lact.	38 %	39 %	35 %	40 %	40 %	35 %	34 %
3rd +lact.	43 %	44 %	50 %	50 %	50 %	50 %	39 %

3.3.4 Stillbirth and calving ease

Assumptions for phenotypic level for stillbirth and calving ease (table 3.7) are averages based on farmer registrations used for breeding value estimation for calving traits. For both stillbirth and calving ease different assumptions are given for first and later calvings. The value of stillbirth depends on profit from raising both heifer and bull calves. There are quite some differences in profit from heifers and bull calves and there are differences in stillbirth rate between sexes. Therefore stillbirth rate for both sexes is included in the calculations. For both sexes, there are less stillborn calves in RDC compared to Holsteins, most pronounced in first calving. Calvings are grouped in four different groups depending on degree of calving difficulties: 1) Easy calving without help; 2) Easy calving with help; 3) Difficult calving without veterinarian assistance; 4) Difficult calving with veterinarian assistance. Group 4 includes caesarean dissection. The assumed Swedish distribution on the four groups is however based on a transformation of the observed 2 point scale. For both first and later calvings, the frequency of easy calving is highest for Jersey. RDC has a frequency of easy calving within first calving, which is 3 to 12 percent higher than Holstein, dependent on country. For later calvings, these differences are smaller.

The work load related to calvings can be found in table 3.15. For time related to calvings it is assumed that a “normal” difficult calving requires extra 1.5 hours work from the herdsmen. Caesarean and dissections require extra 3.35 to 3.70 hours work from the herdsmen. For all countries and breeds it is assumed that a stillborn calf requires extra work of 0.25 hours. In Finland, extra 0.5 hours are added because it is common practice (and allowed) to bury stillborn calves, whereas costs of destruction of stillborn calves are not included in Finland. Furthermore, it is assumed that milk will be retained for 1.2 days following a difficult calving with veterinarian assistance.

Table 3.7 Assumed average phenotypic levels for traits related to still birth and calving ease within the different breeds.

	RDM DNK	SRB SWE	FAY FIN	HOL DNK	HOL SWE	HOL FIN	JER DNK
Stillborn heifer calves, 1st (%)	5.0	4.4	4.8	7.1	8.1	6.3	7.6
Stillborn bull calves, 1st (%)	9.2	5.3	6.7	12.1	10.4	9.3	7.7
Stillborn heifer calves, Later (%)	2.5	3.2	3.1	3.1	3.6	2.1	3.3
Stillborn bull calves, Later (%)	3.6	4.1	3.6	5.0	4.8	2.8	3.7
Easy, 1st (%)	73.5	68.9	63.4	60.3	59.8	57.5	94.1
Easy with help, 1st (%)	19.6	23.3	26.5	32.6	31.2	29.0	4.1
Difficult without vet. ass., 1st (%)	5.4	6.6	9.1	5.8	7.8	12.3	1.1
Difficult with vet. ass., 1st (%)	1.5	1.2	1.0	1.3	1.2	1.2	0.8
Total difficult, 1st (%)	6.9	7.8	10.1	7.1	9.0	13.5	1.9
Easy, Later (%)	87.1	81.8	71.6	77.6	76.6	71.0	97.4
Easy with help, Later (%)	10.3	17.0	22.5	19.0	21.8	23.3	1.8
Difficult without vet. ass., Later (%)	1.6	0.9	5.3	2.2	1.2	5.1	0.4
Difficult with vet. ass., Later (%)	1.0	0.3	0.6	1.2	0.4	0.6	0.4
Total difficult, Later (%)	2.6	1.2	5.9	3.4	1.6	5.7	0.8

3.3.4 Disease Trait

The assumptions for the phenotypic level of disease traits are average figures based on registrations used for breeding values estimation. Values are calculated for five categories of diseases: Mastitis, metabolic diseases, Feet&Legs diseases, early reproductive diseases, and late reproductive diseases. The assumptions used are given in table 3.8 to 3.12.

Table 3.8 Assumed average phenotypic levels for **mastitis** treatments.

	RDM DNK	SRB SWE	FAY FIN	HOL DNK	HOL SWE	HOL FIN	JER DNK
	% incidence of mastitis (first treatments within period)						
-15 – 50 days, 1st lact.	14.3	5.3	6.9	12.1	6.6	9.7	18.4
51 – 305 days, 1st lact.	10.4	4.6	5.9	11.9	6.7	9.3	9.2
-15 – 305 days, 2nd lact.	18.3	8.6	12.0	21.4	12.4	15.3	23.7
-15 – 305 days, 3rd+ lact.	22.2	11.9	14.9	25.9	15.8	18.7	27.3
	% incidence of mastitis (all treatments within period)						
-15 – 50 days, 1st lact.	23.5	8.0	10.5	19.1	10.0	14.7	30.9
51 – 305 days, 1st lact.	17.1	7.3	9.4	18.8	10.6	14.8	15.5
-15 – 305 days, 2nd lact.	32.2	12.7	17.6	36.6	18.4	22.6	40.5
-15 – 305 days, 3rd+ lact.	40.0	17.9	22.5	45.1	23.9	28.2	47.5

Table 3.9 Assumed average phenotypic levels for **metabolic diseases.**

	RDM DNK	SRB SWE	FAY FIN	HOL DNK	HOL SWE	HOL FIN	JER DNK
	% incidence of metabolic diseases (first treatments within period)						
-15 – 305 days, 1st lact.	2.57	1.90	2.65	3.22	2.22	4.89	2.80
-15 – 305 days, 2nd lact.	5.06	3.80	4.12	4.74	4.09	6.08	4.70
-15 – 305 days, 3rd+ lact.	11.68	8.44	9.25	10.07	9.65	12.82	10.6
	% incidence of metabolic diseases (all treatments within period)						
-15 – 305 days, 1st lact.	3.4	2.2	3.1	4.4	2.2	5.9	3.3
-15 – 305 days, 2nd lact.	6.4	4.7	5.2	6.1	5.1	7.6	5.7
-15 – 305 days, 3rd+ lact.	15.5	11.2	12.5	13.2	12.8	17.4	14.0

Table 3.10 Assumed average phenotypic levels for **feet & leg diseases.**

	RDM DNK	SRB SWE	FAY FIN	HOL DNK	HOL SWE	HOL FIN	JER DNK
	% incidence of Feet&Legs diseases (first treatments within period)						
-15 – 305 days, 1st lact.	5.48	2.16	2.03	5.8	3.03	2.29	5.7
-15 – 305 days, 2nd lact.	4.24	1.56	1.17	4.77	2.15	1.52	3.4
-15 – 305 days, 3rd+ lact.	5.47	1.83	1.35	5.66	2.79	1.94	3.9
	% incidence of feet & leg diseases (all treatments within period)						
-15 – 305 days, 1st lact.	7.9	2.4	2.3	8.2	3.5	2.6	7.3
-15 – 305 days, 2nd lact.	5.4	1.7	1.3	6.1	2.3	1.8	4.3
-15 – 305 days, 3rd+ lact.	7.1	1.9	1.6	7.3	3.0	2.2	4.9

Table 3.11 Assumed average phenotypic levels for **early reproductive diseases (infectious).**

	RDM DNK	SRB SWE	FAY FIN	HOL DNK	HOL SWE	HOL FIN	JER DNK
	% incidence of early reproductive diseases (first treatments within period)						
-15 – 40 days, 1st lact.	7.84	1.34	2.36	8.79	2.83	3.91	3.90
-15 – 40 days, 2nd lact.	10.22	2.09	2.52	10.45	3.02	3.07	5.42
-15 – 40 days, 3rd+ lact.	12.93	2.72	3.15	12.61	3.73	3.55	5.61
	% incidence of early reproductive diseases (all treatments within period)						
-15 – 40 days, 1st lact.	9.6	1.4	2.6	10.8	3.1	4.5	4.6
-15 – 40 days, 2nd lact.	11.8	2.3	2.8	11.8	3.3	3.5	6.3
-15 – 40 days, 3rd+ lact.	15.2	2.9	3.5	14.3	4.0	4.0	6.7

Table 3.12 Assumed average phenotypic levels for **late reproductive diseases (hormonal).**

	RDM DNK	SRB SWE	FAY FIN	HOL DNK	HOL SWE	HOL FIN	JER DNK
	% incidence of late reproductive diseases (first treatments within period)						
41 – 305 days, 1st lact.	0.70	4.27	12.25	1.44	6.56	11.17	0.21
41 – 305 days, 2nd lact.	1.09	4.41	11.73	1.79	6.01	10.5	0.29
41 – 305 days, 3rd+ lact.	4.16	4.53	12.83	3.95	5.66	10.49	0.30
	% incidence of late reproductive diseases (all treatments within period)						
41 – 305 days, 1st lact.	0.7	4.9	15.1	1.5	7.9	14.0	0.2
41 – 305 days, 2nd lact.	1.4	5.3	14.6	2.2	7.1	13.2	0.3
41 – 305 days, 3rd+ lact.	5.2	5.6	16.2	4.7	6.7	13.3	0.4

The basic assumptions on cost, extra work and days retained milk is generally taken from the Danish project "Health Economy" (www.cowecon.dk). Costs of veterinarian treatments are assumed to be 20% higher in Sweden than in Denmark and some of the Finnish costs are modified based on Finnish experiences. The assumed costs of veterinarian treatments are given in table 3.13.

In table 3.14 are shown assumptions on average days retained milk after a veterinarian treatment. These assumptions are also picked up from the Danish project Health Economy (www.cowecon.dk).

Finally in table 3.15 the assumptions on extra work related to the traits analysed are presented. The extra work associated with veterinarian treatments are based on the Health Economy project with some national "corrections". The costs of labour is set to 19.60 € per hour in all countries.

Table 3.13 Assumptions on veterinarian cost (€) per case (Medicine included) within the different NAV-areas.

	SWE	DNK	FIN S*	FIN N*
Difficult calving with vet. assistance **	312	260	260	295
Mastitis	162	135	135	149
Metabolic diseases	102	85	102	112
Feet & leg diseases	90	75	90	99
Early reproductive diseases (infectious)	114	95	95	105
Late reproductive diseases (hormonal)	70	58	70	77

* S: South, N: North

** 20% of the veterinarian assisted difficult calvings are caesareans and dissections

Table 3.14 Assumptions on average days of retained milk following different "treatments" within the different NAV-areas.

	SWE	DNK	FIN S*	FIN N*
Difficult calving without vet. assistance	0.00	0.00	0.00	0.00
Difficult calving with vet. assistance	1.20	1.20	1.20	1.20
Mastitis	6.75	6.75	6.75	6.75
Metabolic diseases	1.80	1.80	1.80	1.80
Feet & leg diseases	2.20	2.20	2.20	2.20
Early reproductive diseases (infectious)	3.90	3.90	3.90	3.90
Late reproductive diseases (hormonal)	0.00	0.00	0.00	0.00

* S: South, N: North

Table 3.15 Assumptions on extra work for the herdsman related to AI, calvings and veterinarian treatments of diseases.

	SWE	DNK	FIN S*	FIN N*
One AI, hours/AI	0.25	0.25	0.25	0.25
Heat observation, seconds/day observed	42.00	42.00	42.00	42.00
Stillborn calf, hours/calf	0.25	0.25	0.75	0.75
Easy calving, hours/case	0.20	0.20	0.20	0.20
Difficult calving without vet. ass., hours/case	1.50	1.50	1.50	1.50
Difficult calving with vet. ass., hours/case	3.35	3.35	3.70	3.70
Mastitis, hours/case	1.44	1.44	2.51	2.51
Metabolic diseases, hours/case	1.25	1.25	1.65	1.65
Feet & leg diseases, hours/case	1.43	1.43	1.87	1.87
Early reproductive diseases, hours/case	1.08	1.08	1.78	1.78
Late reproductive diseases, hours/case	0.75	0.75	1.00	1.00

* S: South, N: North

4. Descriptions of trait group procedures

4.1 Production traits (yield)

In NAV nine production traits are evaluated: 305 days milk, protein and fat each in 1st, 2nd and 3rd lactation. A transformation of 305 day production to herd production is needed, as the economy does not depend on 305 days yield, but on average yield from both culled cows and cows with a subsequent lactation. This is most easily obtained by use of a lactation curve model, in combination with the estimated herd structure, the distribution of different lactations, and the number of days in milk for culled cows. The lactation curve model is the basis for calculation of income from milk production and of feed requirements and finally feed costs.

The lactation curve model is a Danish model developed for Microsoft Excel by Østergaard (1999, unpublished). It uses a 5 parameter function to describe the lactation curve and takes into account:

- Breed
- Calving age and parity
- Calving month (not used)
- Days open/calving interval
- Production level given as 305 day production level.

Yield of milk, protein and fat is calculated day by day and summed for days in milk. In the settings used in the TMI-model the days in milk comprise for

- Complete lactations: Calving interval ÷ days dry
- Culled cows: Average days in milk for culled cows.

The most important figures for estimating the value of milk production traits are the sales price of milk and the marginal feed costs. In general higher feed prices compared to milk prices favour functional traits in the breeding goal compared to yield traits. Furthermore an important factor determining marginal feed cost is Marginal Feed Utilization (MFU), as described in chapter 3.

4.2 Beef production

Two beef production traits, net daily gain and EUROP form score, are evaluated. The economic value is evaluated on bull calves only, but it is important to have in mind that the improvement of gain and form score also has an impact on the slaughter value of females (heifers and cows). This effect is not included in the current version of the TMI-model.

Beef production systems are quite similar in Sweden and Finland. Most bull calves are raised in specialized herds to a slaughter weight of 320-330 kg. In Denmark, 70% of bull calves are raised in specialized herds and for RDM and Holstein, approximately 50% of the bull calves are slaughtered at a carcass weight just below 200 kg and the remaining part are slaughtered at an average carcass weight of around 240 kg.

In the model a fixed age at slaughter is assumed. By doing so, the reduced fixed costs (e.g. housing and work load) with improved daily gain are taken into consideration.

In practice a major part of Jersey bull calves are culled at birth. The remaining part are slaughtered at a weight around 200 kg. In the calculation of the value of beef production it is assumed that all Jersey bull calves are raised and slaughtered.

4.3 Fertility

The economic consequences of fertility traits are mostly due to a change in calving interval. This has effect on yearly production per cow. Furthermore, the consequences are related to cost of insemination – and of work related to insemination and heat detection.

The fertility traits currently evaluated in NAV are interval from first to last insemination (IFL) and number of inseminations (AIS) for heifers. For cows, interval from calving to 1st insemination (ICF), IFL, AIS and fertility treatments are evaluated.

The value of AIS depends only on AI-costs, and AI-costs are removed completely from the IFL value. Cost of AI has been discussed intensively. In the AI costs only costs of technician and handling and distribution of semen are included, not the costs related to selection (payment to breeders, testing, and evaluation). In the current model AI-costs are nearly similar (19-21 €/AI) in all countries.

In theory, every single trait should be improved without changing any of the other traits when estimating economic values. However, it is difficult to fulfil this assumption for some of the functional traits, especially for fertility, as some "structural" relationships, which exist between fertility, culling rate, and yield have to be included. An important relationship exists between fertility and yield. Fertility has an impact on yield through the effect of pregnancy. From around 120 days after conception milk yield decreases by around 4-6 kg milk per day (Holstein and RDC). Another important question is whether a shorter calving interval will shorten days in milk (DIM) or days dry. In the basic assumptions, the average days dry are longer than the recommended 45-50 days. It is assumed that a shorter calving interval will reduce average days dry and not average days in milk. In the model, it is assumed that improved fertility does not influence culling rate per year but it reduces culling rate within lactations. This means that number of calves born and milk production per herd per year is improved due to improved fertility.

The fertility is modelled by

- Conception rate. The basic level for conception rate is relatively easy to obtain, even though it is not among the statistics published regularly.
- Insemination rate (heat detection rate). Statistics on this factor are not available from the recording systems. Therefore the basic levels have been estimated from back-calculations of conception rate and statistics on IFL as described in section 3.3.2.
- Another important factor of the fertility model is the limit on length of insemination period. It is assumed to be 168 days (8 inseminations) for both heifers and cows
    - If a heifer is pregnant at the end of the insemination period she is "sold" internally or externally to the assumed price for springing heifers (table 3.3). If she is not pregnant at the end of the period then she is sold at slaughter value. If there is a deficit of pregnant heifers then heifers are bought into the herd such that there are always enough heifers available for replacement, i.e. cow replacement rate is independent of number of heifers available internally.
    - Change of insemination period for cows does not have an impact on replacement rate, as it is the case for heifers. One reason is that replacement rate in cows (longevity) is one of the traits in the analysis and therefore by definition has to be constant. Another reason is that modelling of this interaction would be more complicated because cow replacement also depends on other factors than fertility.

4.4 Calving traits

In the assessment of economic value of calving traits, the costs of stillbirth and calving difficulty are taken into account. Costs of stillbirth comprise mostly lost income from raising heifers and bull calves but also from extra work and cost of destruction. Costs of calving difficulty are mostly extra work and veterinarian cost related to difficult calvings, but not costs due to subsequent complications since they are taken into account in the group of "other diseases".

Stillbirth

Generally for all countries and breeds it is assumed that a stillborn calf require extra work of 0.25 hours. In Finland extra 0.50 hours are added because it is common practice (and allowed) to bury stillborn calves, whereas costs of destruction of stillborn calves are not included in Finland.

Calving difficulty

When percent difficult calvings are changed, a proportional change in percent difficult calvings with veterinarian and without veterinarian assistance is assumed. It is assumed that 20% of difficult calvings with veterinarian assistance require caesarean or dissections (higher cost). The same figure is used across countries and breeds.

The outset for the calculations is the basic frequency distribution of the 4 categories. Assuming an underlying normal distribution (N(0,1)) the 3 thresholds between categories are determined.

The method used – step by step:

- An average on the 4 point scale is calculated from the basic distribution
- Average costs of difficult calvings for the basic distribution are calculated
- The mean of the normal distribution is then moved a little
  - A new frequency distribution is calculated
  - A new mean of the 4-point scale is calculated
  - Average costs for the new distribution are calculated
- Then the values are determined by comparison of:
  - Difference in average on 4-point scales is calculated
  - Differences in costs are calculated
  - Costs divided by change on 4-point scale are basic for calculation of value. (The TMI program takes care of number of expressions per year)
  - Values are calculated separately for 1st and for later calvings, for breeds and countries.

4.5 Udder health

The costs related to udder health are costs of veterinarian treatments, extra work for the herdsman, and amount of milk discarded due to treatment with antibiotics.

The udder health traits currently evaluated in NAV are udder diseases before day 50 in 1st lactation, udder diseases 50-305 days in 1st lactation, udder diseases before day 305 in 2nd lactation, and udder diseases before day 305 in 3rd lactation, all measured as a binary trait. Somatic cell count is an important information trait for the estimation of breeding values for udder health.

In the economic evaluation of udder health the importance is related to the total number of cases, and not to the occurrence measured as a binary trait. Therefore, the relationship between those two figures must be known. Input to the calculation is the average of the traits evaluated and the corresponding total number of cases. It is assumed that a change in the evaluated trait will change the total number of cases proportionately.

4.6 Resistance against other diseases

Other diseases are evaluated as 12 traits: Metabolic diseases, feet and leg diseases, early reproductive diseases and late reproductive diseases - all in 1st, 2nd and 3rd lactation. The calculations within groups follow same principles as described for mastitis above.

4.7 Conformation traits, milking speed and temperament

The weights used to calculate breeding value for each of these three EBVs (Body, Feet&Legs and Udder) from each of the linear traits has been suggested by the breed associations. The weights used can be found on NAV's homepage, www.nordicebv.info

The task of the project group was not to re-estimate these weights – but only to estimate the economic importance of the main characters Body, Feet&Legs and Udder relative to other traits in the total merit index.

Therefore the set up for this trait group is somewhat atypical compared to the other trait groups. The traits to be analyzed are a kind of phenotype for Body, Feet&Legs and Udder.

The basic economic assumptions are made by (subjective) assessment of the extra work-load in an average herd. The current figures in the TMI-program are taken from the Danish 2002 report on economic weights (Pedersen et al., 2003):

- Body: There is no impact on the work load if all traits included in "Body" were linearly scored 1 point away from the optimum.
- Udder: If all traits included in Udder were linearly scored 1 point away from the optimum, the extra work was assumed to be 15 minutes per day per 70 cows.
- Feet&Legs: If all traits included in Feet&Legs were linearly scored 1 point away from the optimum, the extra work was assumed to be 10 minutes per day per 70 cows.

The two farmer-evaluated traits Milking Speed and Temperament are less complicated, because the recorded score can directly be evaluated. If milking speed of all cows is one unit less it is assumed that the extra work would be 10 minutes per day per 70 cows. If the temperament of all cows is 1 unit lower, the extra work was assumed to amount to be 5 minutes per day per 70 cows.

4.8 Longevity

The value of longevity is found via variation in the traits % culled in 1st lactation, % culled in 2nd lactation, and % culled in 3rd and later lactation. It is well known that the breeding value for longevity is heavily influenced by fertility, udder health and other diseases and to some degree of conformation of udder and of Feet&Legs. Due to model limitations, the effect of reduced culling on the value of these traits is not included. Therefore, as much value as possible is transferred from longevity to the other trait in the TMI.

This transfer is based on analyses of the relationship between longevity and the other trait in the TMI. The value expressing how large part of the variance in longevity to be explained by the five traits (three in Jersey) is given in table 4.1 as well as the relative size of these regression coefficients determining how much of the transferred value each trait should "receive".

Table 4.1 shows the main results for the three breed groups. How this redistribution is done is illustrated for Holstein. In Holstein, the average value of longevity was 0.51 €/day. This will give an index weight of 0.43 (table 5.4). 70% of this weight should be transferred to other traits, i.e.

0.34 should be transferred, and 0.15 is the remaining value. The 0.34 is redistributed as given below

- 28% of 0.34 = 0.09 should be added to the index weight for Fertility
- 32% of 0.34 = 0.11 should be added to the index weight for Udder health
- 16% of 0.34 = 0.05 should be added to the index weight for Other diseases
- 16% of 0.34 = 0.06 should be added to the index weight for Feet&Legs
- 8% of 0.34 = 0.03 should be added to the index weight for Udder

Table 4.1 The amount of longevity explained by other traits and their relative importance

	Holstein	RDC	Jersey
% of longevity value to be transferred by other indexes	70%	70%	50%
Most important trait and their relative importance			
Growth	-	-	-
Fertility	0.28	0.24	-
Birth index	-	-	-
Calving index	-	-	-
Udder health	0.32	0.26	0.72
Other disease	0.16	0.17	-
Body	-	-	-
Feet&Legs	0.16	0.08	0.14
Udder	0.08	0.25	0.14
Milk ability	-	-	-
Temperament	-	-	-

4.9 Somatic Cell Count (SCC)

The economic value of somatic cell count was evaluated in the model, but it turned out that the importance of this trait was insignificant. Therefore results on this trait are not included.

Three different traits are evaluated: SCC 1st lactation, SCC 2nd lactation, SCC 3rd lactation (and later), whereas deductions in milk price due to SCC levels are made on total herd production.

Basically, the economic value of SCC is a correction of the milk price. This is solved by calculation of the average herd SCC. Based on this average, a distribution of herds on SCC-classes is calculated. Based on that distribution an average change in milk prices is determined.

5. Results for traits and sub indexes

5.1 Value of individual traits

The results from the TMI program are given in Euro per unit change of the trait. The results are of course dependent on the assumptions. Table 5.1 below gives the average weights (average of Denmark, Sweden and Finland “South”), for the traits within Holstein and the deviation from the average for the different production environments. Table 5.2 and 5.3 show the corresponding results for the RDC and for Jersey.

Table 5.1 Average NAV-TMI economic values for **Holstein** (average of Denmark, Sweden and Finland "South"), and NAV-TMI economic values in different production environments.

Trait	Unit	Average EURO per unit	Denmark	Sweden	Finland "South"
MILK PRODUCTION					
Milk	Kg	**-0.030**	-0.049	-0.052	0.012
Fat	Kg	**1.28**	1.62	1.64	0.59
Protein	Kg	**4.60**	4.34	4.51	4.95
Standard milk	Kg	**0.181**	0.167	0.170	0.205
BEEF PRODUCTION					
Net daily gain	Kg/day	**201.3**	187.2	222.7	193.8
EUROP form score	Score	**13.8**	11.5	14.6	15.3
CALVING TRAITS					
% stillborn, 1st	%-units	**2.0**	1.7	2.2	2.2
Easy calving, 1st	4 point scale	**11.0**	11.2	11.7	10.1
% stillborn, later	%-units	**3.3**	2.7	3.3	3.9
Easy calving, later	4 point scale	**14.9**	20.0	11.1	13.5
FEMALE FERTILITY					
Heifer - first to last	Day	**0.73**	1.16	0.54	0.50
Cow – calv. to first	Day	**0.62**	0.43	0.61	0.81
Cow - first to last	Day	**2.35**	2.63	2.00	2.41
Heifer - no. of ins.	AIS	**10.17**	9.05	10.50	10.97
Cow – no. of ins.	AIS	**35.55**	39.13	31.40	36.11
MASTITIS*					
Mastitis, 1st	%-units	**1.50**	1.45	1.56	1.50
Mastitis, 2nd	%-units	**1.13**	1.15	1.09	1.15
Mastitis, 3rd	%-units	**1.44**	1.42	1.35	1.55
Mastitis, all lact.	%-units	**4.07**	4.02	4.00	4.20
OTHER DISEASES**					
Metabolic	%-units	**1.88**	1.78	1.76	2.11
Feet&Legs	%-units	**1.75**	1.77	1.62	1.88
Early reproductive	%-units	**2.00**	1.90	1.96	2.12
Late reproductive	%-units	**1.05**	0.88	1.06	1.21
LONGEVITY					
Average, culling	Day	**0.51**	0.51	0.42	0.63
CONFORMATION					
Body	Point	**0.0**	0.0	0.0	0.0
Udder	Point	**25.6**	25.6	25.6	25.6
Feet&Legs	Point	**17.0**	17.0	17.0	17.0
Milking speed	Point	**17.0**	17.0	17.0	17.0
Temperament	Point	**8.5**	8.5	8.5	8.5

* The economic value calculated is the value of 1% change in incidence (e.g. from 15% mastitis to 16% mastitis) corrected for the number of animals in the different groups.

** The economic value calculated is the value of 1% change in incidence.

Table 5.2 Average NAV-TMI economic values for the **Nordic Red Dairy Cattle (RDC)** (average of Denmark, Sweden and Finland "South"), and NAV-TMI economic values in different production environments.

Trait	Unit	Average EURO per unit	Denmark	Sweden	Finland "South"
		MILK PRODUCTION			
Milk	Kg	**-0.029**	-0.049	-0.054	0.015
Fat	Kg	**1.33**	1.63	1.69	0.67
Protein	Kg	**4.81**	4.35	4.61	5.49
Standard milk	Kg	**0.190**	0.167	0.174	0.230
		BEEF PRODUCTION			
Net daily gain	Kg/day	**222.8**	204.6	266.2	197.5
EUROP form score	Score	**13.6**	11.8	14.6	14.5
		CALVING TRAITS			
% stillborn, 1st	%-units	**2.01**	1.71	2.22	2.09
Easy calving, 1st	4 point scale	**11.35**	12.95	12.21	9.02
% stillborn, later	%-units	**3.37**	2.99	3.44	3.68
Easy calving, later	4 point scale	**15.62**	23.66	10.46	12.93
		FEMALE FERTILITY			
Heifer – first to last	Day	**0.61**	0.61	0.56	0.66
Cow – calv. to first	Day	**0.56**	0.56	0.62	0.51
Cow - first to last	Day	**1.78**	1.35	1.41	2.56
Heifer - no. of ins.	AIS	**10.14**	9.26	10.69	10.46
Cow – no. of ins.	AIS	**27.24**	17.94	20.38	43.41
		MASTITIS*			
Mastitis, 1st	%-units	**1.46**	1.44	1.52	1.41
Mastitis, 2nd	%-units	**1.05**	1.07	1.00	1.08
Mastitis, 3rd	%-units	**1.49**	1.63	1.41	1.44
Mastitis, all lact.	%-units	**4.00**	4.14	3.93	3.93
		OTHER DISEASES**			
Metabolic	%-units	**1.87**	1.77	1.85	1.98
Feet&Legs	%-units	**1.70**	1.78	1.55	1.77
Early reproductive	%-units	**1.93**	1.92	1.91	1.94
Late reproductive	%-units	**1.04**	0.92	1.06	1.14
		LONGEVITY			
Average, culling	Day	**0.38**	0.43	0.32	0.41
		CONFORMATION			
Body	Point	**0.0**	0.0	0.0	0.0
Udder	Point	**25.5**	25.5	25.5	25.5
Feet&Legs	Point	**17.0**	17.0	17.0	17.0
Milking speed	Point	**17.0**	17.0	17.0	17.0
Temperament	Point	**8.5**	8.5	8.5	8.5

* The economic value calculated is the value of 1% change in incidence (e.g. from 15% mastitis to 16% mastitis) corrected for the number of animals in the different groups.

** The economic value calculated is the value of 1% change in incidence.

Table 5.3 NAV-TMI economic values for the **Jersey** under Danish production circumstances.

Trait	Unit	Average EURO per unit
	MILK PRODUCTION	
Milk	Kg	**-0.046**
Fat	Kg	**1.55**
Protein	Kg	**4.15**
Standard milk	Kg	**0.16**
	BEEF PRODUCTION	
Net daily gain	Kg/day	**45.6**
EUROP form score	Score	**10.1**
	CALVING TRAITS	
%stillborn, 1st	%-units	**0.79**
Easy calving, 1st	4 point scale	**15.7**
%stillborn, later	%-units	**1.46**
Easy, later	4 point scale	**33.7**
	FEMALE FERTILITY	
Heifer – first to last	Day	**0.93**
Cow – calv. to first	Day	**0.28**
Cow - first to last	Day	**1.61**
Heifer - no. of ins.	AIS	**9.27**
Cow – no. of ins.	AIS	**27.14**
	MASTITIS*	
Mastitis, 1st	%-units	**1.35**
Mastitis, 2nd	%-units	**1.01**
Mastitis, 3rd	%-units	**1.75**
Mastitis, all lact.	%-units	**4.11**
	OTHER DISEASES**	
Metabolic	%-units	**1.70**
Feet&Legs	%-units	**1.69**
Early reproductive	%-units	**1.91**
Late reproductive	%-units	**0.94**
	LONGEVITY	
Average, culling	Day	**0.40**
	CONFORMATION	
Body	Point	**0.0**
Udder	Point	**25.6**
Feet&Legs	Point	**17.0**
Milking speed	Point	**17.0**
Temperament	Point	**8.5**

* The economic value calculated is the value of 1% change in incidence (e.g. from 15% mastitis to 16% mastitis) corrected for the number of animals in the different groups.

** The economic value calculated is the value of 1% change in incidence.

5.2 Index weights

Based on the NAV-TMI economic values for the individual traits the index weights for the standardized sub-indices included in the TMI are calculated. The standardization is done with the purpose to achieve a standard deviation of 10 index units for different traits for newly tested AI-bulls with breeding values acceptable for publication. Due to the standardisation, the index weights also depend on the accuracy of the EBVs for the different traits. The index weights for the different traits are presented in table 5.4 - 5.6

Based on the results in table 5.1 - 5.3 a simple procedure for the calculation of index weights is as follows:
For each sub-index the value of each trait is calculated. It is a sub-index EBV expressed in € (€EBV)

- The standard deviation of €EBV is calculated (SD(€EBV))
- The €EBV can then be converted to an index with a standard deviation of 10 by multiplying with 10/SD(€EBV)
- The factor SD(€EBV)/10 is the value of an index unit.
- The index weights shown in table 5.4 - 5.6 are these index values relative to the value of milk production.

We need to express some of the individual EBVs as indices as well. Therefore, in practice, the procedures are slightly different, but the results are the same.

Table 5.4 Weight factors to be given to the different sub indices in the present TMI and the proposed NAV-TMI weights for **Holstein**. The weights are scaled in that way that weight on yield is equal to 1 (the weights before redistributing value of longevity are given in parenthesis).

Trait	Denmark	Sweden	Finland	Denmark	Sweden	Finland	
	S-index	Tjur index	Kokonaisja-losstusarvo	NAV TMI	NAV TMI	NAV TMI	Holstein Average NAV-TMI
Yield index	1.00	1.00	1.00	**1.00**	**1.00**	**1.00**	**1.00***
Growth	0.14	-	-	**0.09**	**0.10**	**0.07**	**0.08**
Fertility	0.26	0.50	0.30	**0.48** (0.38)	**0.38** (0.29)	**0.38** (0.28)	**0.41** (0.32)
Birth index	0.17	0.19	-	**0.21**	**0.22**	**0.19**	**0.20**
Calving index	0.17	0.37	0.10	**0.20**	**0.25**	**0.21**	**0.22**
Udder health	0.42	0.48	0.50	**0.49** (0.37)	**0.47** (0.37)	**0.43** (0.32)	**0.46** (0.35)
Other diseases	0.06	0.06	-	**0.17** (0.11)	**0.16** (0.11)	**0.17** (0.11)	**0.16** (0.11)
Body	0.06	-	-	**0.00**	**0.00**	**0.00**	**0.00**
Feet&Legs	0.16	0.29	0.10	**0.11** (0.05)	**0.10** (0.05)	**0.10** (0.04)	**0.10** (0.04)
Udder	0.26	0.29	0.30	**0.13** (0.10)	**0.12** (0.10)	**0.11** (0.08)	**0.12** (0.09)
Milk ability	0.17	-	-	**0.12**	**0.11**	**0.09**	**0.11**
Temperament	0.05	-	-	**0.05**	**0.05**	**0.04**	**0.04**
Longevity	0.17	0.16	-	**0.16** (0.52)	**0.13** (0.43)	**0.16** (0.52)	**0.15** (0.49)

* The economic value of one index unit for yield in the Average NAV-TMI index is 7.61 €. The economic value per index unit for other traits in the Average NAV-TMI index has the same ratio compared to yield as the ratio between index weights (e.g. the economic weight for one index unit for udder health is 0.46*7.61 €=3.50 €)

Table 5.5 Weights factors to be given to the different sub indices in the present TMI and the proposed NAV-TMI weight for **Red Dairy Cattle (RDC).** The weights are scaled is that way that weight on yield is equal to 1 (the weights before redistributing the value of longevity are given in parenthesis)

	Denmark	Sweden	Finland	Denmark	Sweden	Finland	
Trait	S-index	Tjur index	Kokonaisja-losstusarvo	NAV TMI	NAV TMI	NAV TMI	RDC Average NAV-TMI
Yield index	1.00	1.00	1.00	**1.00**	**1.00**	**1.00**	**1.00***
Growth	0.13	-	-	**0.12**	**0.13**	**0.09**	**0.11**
Fertility	0.19	0.43	0.33	**0.26** (0.20)	**0.25** (0.21)	**0.30** (0.26)	**0.28** (0.23)
Birth index	0.13	0.10	-	**0.17**	**0.18**	**0.14**	**0.15**
Calving index	0.10	0.13	-	**0.13**	**0.14**	**0.10**	**0.13**
Udder health	0.45	0.43	0.44	**0.40** (0.33)	**0.36** (0.31)	**0.28** (0.23)	**0.34** (0.29)
Other diseases	0.09	0.06	-	**0.15** (0.11)	**0.14** (0.11)	**0.12** (0.09)	**0.13** (0.10)
Body	-	-	-	**0.00**	**0.00**	**0.00**	**0.00**
Feet&Legs	0.13	0.20	0.11	**0.08** (0.06)	**0.08** (0.06)	**0.0** (0.05)	**0.07** (0.06)
Udder	0.10	0.30	0.44	**0.17** (0.10)	**0.15** (0.10)	**0.12** (0.08)	**0.14** (0.09)
Milk ability	0.16	-	-	**0.08**	**0.08**	**0.06**	**0.07**
Temperament	0.10	-	-	**0.03**	**0.03**	**0.03**	**0.03**
Longevity	0.15	0.14	-	**0.11** (0.37)	**0.08** (0.26)	**0.08** (0.26)	**0.09** (0.28)

* The economic value of one index unit for yield in the Average NAV-TMI index is 8.33 €. The economic value per index unit for other traits in the Average NAV-TMI index has the same ratio compared to yield as the ratio between index weights (e.g. the economic weight for one index unit for udder health is 0.34*8.33 €=2.85 €)

Table 5.6 Weights factors to be given to the different sub indices in the proposals of NAV-TMI indices for **Jersey** and the present values. The weights are scaled is that way that weight on yield is equal to 1 (the weights before redistributing the value of longevity are given in parenthesis)

Trait	Jersey Denmark	Jersey
	S-index	NAV-TMI
Yield index	1.00	**1.00***
Growth	-	**0.03**
Fertility	0.23	**0.23**
Birth index	0.04	**0.07**
Calving index	0.08	**0.06**
Udder health	0.33	**0.51** (0.40)
Other diseases	0.07	**0.05**
Body	-	**0**
Feet&Legs	0.12	**0.06** (0.04)
Udder	0.23	**0.15** (0.13)
Milk ability	0.05	**0.11**
Temperament	0.02	**0.03**
Longevity	0.18	**0.14** (0.28)

* The economic value of one index unit for yield is 6.00 €. The economic value per index unit for other traits has the same ratio compared to yield as the ratio between index weights (e.g. the economic weight for one index unit for udder health is 0.51*6.00 €=3.06 €)

6. Genetic Gain - using the proposed economic weights

The index weights described in the previous chapter do not effectively describe the genetic progress that can be obtained using TMI. However, genetic correlations between TMI and the sub-indices for AI-bulls could give an estimate for the obtained genetic progress for the traits in the breeding goal, even though there is a tendency towards overestimation of the genetic gain for low heritability traits using this method, because it ignores bull dam selection. Another disadvantage of this approach is that it is quite sensitive to number of bulls included in the analyses and to the number of bull sires represented in the sample.

The correlations shown in the present chapter are correlations between TMI and sub indices based on EBV's from progeny tested bulls born in 1999, 2000 and 2001 in Finland, Sweden and Denmark. As mentioned above, the correlations are quite rough, and they are dependent on the number of sires included. If the number is low as in the present situation (no groups above 1000 bulls) then the correlations will depend on some dominant sires of sons used in that group. That is probably the reason for the relatively large differences in correlations between NAV-TMI and sub-indices in different countries in table 6.1 (Holsteins). For the correlations based on the Nordic Red Dairy Breeds (table 6.2) the differences can also be due to a different breed composition.

However, the correlations can be used as an indicator for the change in the direction of the genetic progress going from the national index to an average NAV-TMI index.

Table 6.1 Correlation between TMI and sub indices within country using present total merit indices or proposed average NAV-TMI weights for **Holstein.**

Trait	Denmark		Sweden		Finland	
	S-index	Average NAV-TMI 905 sires	Tjur index	Average NAV-TMI	Koko-naisja-losstusarvo	Average NAV-TMI
Yield index	0.53	0.48	0.42	0.64	0.75	0.62
Growth	0.08	0.05	-0.13	0.05	-	-
Fertility	0.32	0.45	0.32	0.20	0.00	0.32
Birth index	0.31	0.35	0.44	0.43	0.06	0.20
Calving index	0.37	0.42	0.53	0.49	0.23	0.31
Udder health	0.41	0.43	0.39	0.23	0.48	0.38
Other diseases	0.44	0.54	0.23	0.30	0.34	0.46
Body	0.02	-0.05	0.08	0.03	0.20	0.02
Feet&Legs	0.14	0.09	0.29	0.04	0.11	-0.03
Udder	0.45	0.38	0.35	0.17	0.42	0.23
Milk ability	0.21	0.16	0.01	0.09	0.14	0.12
Temperament	0.05	0.00	-0.01	0.13	0.10	0.08
Longevity	0.49	0.52	0.44	0.46	0.36	0.45

Table 6.2 Correlation between the total merit index and sub indices within country using present total merit indices or proposed NAV-TMI weights for **Red Dairy Cattle (RDC).**

Trait	RDM – Denmark		SRB – Sweden		FAY– Finland	
	S-index	Average NAV-TMI 127 sires	Tjur Index	Average NAV-TMI	Koko-naisja-losstusarvo	Average NAV-TMI
Yield index	0.64	0.70	0.52	0.76	0.66	0.79
Growth	-0.02	-0.01	0.21	0.38	-	-
Fertility	0.08	0.21	0.34	0.29	0.19	0.17
Birth index	0.21	0.21	0.17	0.25	0.0	0.17
Calving index	-0.05	-0.02	0.32	0.31	0.15	0.25
Udder health	0.55	0.50	0.38	0.17	0.32	0.18
Other diseases	0.43	0.49	0.09	0.16	0.09	0.14
Body	-0.12	-0.15	0.12	0.02	0.19	0.11
Feet&Legs	0.02	0.00	0.14	-0.08	0.14	0.09
Udder	0.36	0.34	0.34	0.07	0.40	0.14
Milk ability	0.31	0.23	0.03	0.12	0.12	0.24
Temperament	0.16	0.09	-0.01	0.12	0.11	0.23
Longevity	0.61	0.51	0.49	0.44	0.27	0.23

Table 6.3 Correlation between the total merit index and sub indices using present total merit indices or proposed NAV-TMI weights for **Jersey**.

Trait	Jersey – Denmark	
	S-index	NAV-TMI(189 sires)
Yield index	0.74	0.70
Growth	0.15	0.19
Fertility	0.36	0.21
Birth index	0.20	0.22
Calving index	-0.16	-0.21
Udder health	0.43	0.50
Other diseases	0.31	0.26
Body	-0.21	-0.22
Feet&Legs	0.24	0.23
Udder	0.24	0.23
Milk ability	-0.04	0.00
Temperament	0.34	0.33
Longevity	0.30	0.29

7. Sensitivity Analyses

The results of the NAV-TMI project are based on one set of economic and biological assumptions. Of course these assumptions can be discussed. In order to point out the sensitivity towards changes in the most important assumptions, a number of alternative analyses were made.

The following changes towards economic assumptions have been analysed separately. Results are given in table 7.1, 7.2 and 7.3.

1. Sales value of milk increased by 0.03 € (10%). For DNK and SWE sales value of protein, fat and fluid were changed proportionately. For Finland 0.03 € was added to milk price. That has some effect on the separate value of milk, protein and fat, but only total value of milk production is included in the comparison
2. Feed cost was increased by 10%
3. Sales value of beef was increased by 10% (all types i.e. heifer, cows, bull calves)
4. The price differences between EUROP form classes were increased by 10%
5. Value of pregnant heifer was reduced to the slaughter value (approximately 50% of the value used in the standard set up)
6. Labour costs were increased by 10%
7. Veterinarian cost was increased by 10%
8. 20 € was added to cost per AI. This corresponds to the amount charged to farmers per AI.

Additional comments to the results:

- Results from all sensitivity analysis are given for Nordic averages only, but in general the effects of the changes in the assumptions are proportional within countries
- The index weights are not calculated for the different sensitivity analyses, but if all traits within a trait group show similar effect of a change in assumptions then the index weights will change proportionately.
- The results are all expressed as percent deviation from "standard" average NAV-TMI within breed group. However, for the cow fertility trait: Interval from calving to 1st insemination, the "standard" value is so close to zero that percent deviation is not very informative and results on this trait will not be commented
- Results for the trait "number of inseminations" (AIS) are not presented. The results for AIS are included in the results for "Interval from 1st to last insemination" (IFL)
- Note also that the results on AI-cost and on heifer value are consequences of very large changes in assumptions (100% increase/50% decrease) whereas the remaining results represent somewhat more moderate (reasonable) changes in assumptions.

7.1 Sales value of milk

A 10% increase in sales value per kg milk will increase the value of milk by 16%-17%. But also:

- Value of longevity will increase (5%-9%)
- Value of cow fertility (IFL/AIS) increases by 1%-2%
- All disease traits where milk is retained due to veterinarian treatment will have a slightly increased value if milk value increases (1%-2%)
- Calving ease will have a very small increased value due to retained milk after veterinarian treatment.

7.2 Marginal feed costs

A 10% increase in marginal feed cost will decrease value of milk production by 7.2%-7.5%. Additionally increased feed cost will have a small effect on:

- Value of longevity
- Value of fertility
- Value of stillbirth because costs of milk for feeding of calves increased.

Note that the value of diseases does not change – because the model "assumes" that cost of producing the milk is the same if it is retained or not. It is only the sales value of milk that has an effect on value of diseases.

7.3 Carcass value (sales value per kg carcass)

Opposite to common practice the model assumes that bull calves are slaughtered at a fixed age (common practice is slaughter at a fixed weight/size). When we use a fixed age we do not need to define saved fixed cost (housing, work) due to a shorter growing period. The value of increased growth rate depends on the increased carcass weight minus the extra production costs.

If the sales value of carcass is increased by 10%, the value of growth rate increases by 30% for the large breeds and much more in Jersey. Moreover:

- The value of stillbirth increases by 10%
- The value of heifer fertility decreases by 4%-5% (The value is reduced because the span between the value of a pregnant heifer and the slaughter value of a heifer becomes smaller)
- The value of cow fertility increases slightly (2%)
- The value of longevity decreases by 4%-7%.

7.4 EUROP (form score)

If the differences between EUROP form classes become 10% larger, then the value of EUROP form score also increase by 10%. In RDC and Holstein the increase is slightly lower than 10% due to a scaling effect when calculating the average across counties.

Additionally, an increase in payment for EUROP form score has a small insignificant effect on the value of

- Stillbirth rate
- Cow fertility
- Longevity.

7.5 Sales value of pregnant heifer

The sales value of a pregnant heifer compared to her slaughter value is an important factor in estimation of the value of stillbirth rate, fertility and longevity.

The effect on the stillbirth rate is due to the fact that the value of stillbirth relies heavily on the profit from the production of heifer and bull calves and also on the number produced. The profit from bull calf production is low (especially for Jersey). Therefore, the profit from heifer production determines a large part of the value of stillbirth rate. The higher the sales value of a heifer is assumed to be, the higher is the value of still birth rate. In the TMI-model, heifers are either sold as pregnant heifers or they are slaughtered. In the standard set up, the value of a pregnant heifer is approximately twice as large as the slaughter value. As a consequence the value of stillbirth is affected by:

- The difference between the value of pregnant heifer and her slaughter value
- The rate of pregnant heifers. This rate is determined by the fertility of heifers and the assumptions connected to fertility.

The value of heifer fertility also depends on difference between value of pregnant heifer and slaughter value. If the sales value of a pregnant heifer is reduced to the slaughter value, then other traits will be affected as well (note that this means a 50% reduction in sales value)

- The value of stillbirth rate will decrease by 40% in the large breeds and 90% in Jersey. In Jersey, we obtain the largest effect because the profit from bull calf production is so low.
- The value of heifer IFL is reduced by 30%-50%
- The value of cow IFL is reduced by 10%-15%
- The value of longevity is reduced by 40%-50%, because the costs of replacement heifers are low.

7.6 Labour cost

If labour costs are increased by 10% then the value of a number of traits are increased a little (1% - 4%): Stillbirth, calving ease, heifer and cow fertility, and disease traits. However, the largest effects are on the value of conformation traits, because these depend on labour costs. Only increased labour costs are directly reflected in the value of conformation traits.

7.7 Veterinarian costs

If veterinarian costs are increased by 10%:

- The value of calving ease and most disease traits increase by 6% - 8%
- The value of cow fertility decrease slightly (minor changes in cost per kg milk produced).

7.8 Insemination costs

In the standard set up of the TMI-model the cost of an insemination is assumed to be around 20 € and include only the basic cost of semen production and of the technician. It has been discussed if the cost of breeding should be included. If breeding cost is included the cost of an insemination would increase by 20 €.

If 20 € is added to insemination costs the following changes will appear:

- The value of heifer and cow IFL will increase by 30%-40%
- The value of stillbirth will decrease by 2%-3% in the large breed and 7% in Jersey. The value of stillbirth relies on the profit from production of heifer and bull calves and also on the number produced. If insemination costs increases the costs of inseminating heifers also increases and the profit from heifer production decreases
- The value of longevity decreases by 2%-4%. With higher price for AI, the reduction of cost by improvement of longevity becomes smaller.

7.9 Value of fertility

The model for calculating value of fertility is not straight forward. Therefore, some additional analyses of sensitivity were made for some of the assumptions.

The fertility is modelled by:

- Conception rate. The basic level for conception rate is relatively easy to obtain even though it is not among the statistics published regularly
- Insemination rate (heat detection rate). Statistics on this factor are not available from the recording systems. Therefore the basic levels were estimated from back-calculations conception rate and statistics on IFL
- Another important factor of the fertility model is the limit on the length of the insemination period. It is assumed to be 168 days (8 inseminations) for both heifers and cows
  - If a heifer is pregnant at the end of the insemination period, she is “sold” internally or externally to a high value. If she is not pregnant at the end of the period, then she is sold at slaughter value. If there is a deficit of pregnant heifers, then heifers are bought

into herd so that there are always enough heifers available for replacement, i.e. the cow replacement rate is independent of the number of heifers available internally

- The change of insemination period for cows does not have any impact on the replacement rate, as it is the case in heifers. One reason is that replacement rate in cows (longevity) is one of the traits in the analysis and therefore by definition has to be constant. Another reason is that modelling of this interaction would be more complicated because cow replacement depends on other factors than fertility.

The following changes in biological/management assumptions were analysed separately.

1. Insemination rate increased by 5 percent units (for both heifers and cows) to mimic the introduction of new observation tools. This change could also mimic the effect of introducing new heat detection systems. The effect was that the value of heifer fertility decreased by 10%. When the insemination rate increases, the pregnancy rate increases as well and the value of improving fertility becomes smaller. The value of cow fertility decreases by around 7%. Additionally, the value of stillbirth rate is marginally increased due to a slightly lower number of inseminations. Also for diseases in later lactations, a marginal increase in value is observed due to a small change in distribution of lactations.

2. The maximum number of insemination periods decreased to 6 for heifers (insemination period max 126 days). This could also mimic the situation in a system with more strict seasonal matings. The effect was that the value of heifer IFL increased by around 80%. A shorter insemination period reduced the value of stillbirth rate by around 2%. For cow fertility, disease traits, and longevity, marginal changes were observed.

3. The maximum number of insemination periods decreased to 6 for cows (insemination period max 126 days). This could also mimic the situation in a system with more strict seasonal matings. The effect was that the value of cow IFL increased by around 50%. Besides, a marginal effect on a number of traits in other later lactations was observed, due to changes in the distribution of lactations (later lactations started per year, due to a shorter calving interval).

Table 7.1 Holstein sensitivity analyses presented as % deviation from average.

		HOL average	Sales Value +10%	Feed costs +10%	Carcass Value +10%	Value of EUROP +10%	Heifer Value -50%	Labour Costs +10%	Vet. Costs +10%	AI + 20€ +100%
Alternative no.			**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
					MILK PRODUCTION					
Standard milk	**Kg**	**0.181**	**16.0%**	**-7.3%**	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
					BEEF PRODUCTION					
Net daily gain	**Kg/day**	**201.3**	0.0%	0.0%	**32.7%**	-0.9%	0.0%	0.0%	0.0%	0.0%
EUROP form score	**Score**	**13.8**	0.0%	0.0%	0.0%	**9.4%**	0.0%	0.0%	0.0%	0.0%
					CALVING TRAITS					
%stillborn, 1^{st}	**%-unit**	**2.05**	0.0%	-0.7%	**9.9%**	-0.3%	**-40.4%**	-0.1%	0.0%	-2.5%
%stillborn, later	**%-unit**	**3.30**	0.0%	-0.7%	**9.7%**	-0.3%	**-41.1%**	-0.1%	0.0%	-2.5%
easy calvings, 1^{st}	**Point**	**10.99**	0.2%	0.0%	0.0%	0.0%	0.0%	4.4%	**5.4%**	0.0%
easy, later	**Point**	**14.86**	0.2%	0.0%	0.0%	0.0%	0.0%	4.1%	**5.6%**	0.0%
					FEMALE FERTILITY					
Heifer, 1st to last AI	**Day**	**1.10**	0.0%	-0.2%	**-5.4%**	0.0%	**-44.2%**	2.0%	0.0%	**32.3%**
Cows, calv. to 1^{st} AI	**Day**	**0.62**	7.1%	-5.7%	11.1%	-0.3%	-65.7%	-2.5%	-2.3%	-20.5%
Cow, 1st to last AI	**Day**	**4.02**	1.1%	-0.8%	1.6%	0.0%	**-9.7%**	3.6%	-0.3%	**41.1%**
					MASTITIS					
Mastitis, -50d. 1^{st}	**%-unit**	**1.503**	2.3%	0.0%	0.0%	0.0%	0.0%	1.5%	**6.1%**	0.0%
Mastitis, +50d, 1^{st}	**%-unit**	**1.551**	2.3%	0.0%	0.0%	0.0%	0.0%	1.5%	**6.1%**	0.0%
Mastitis, 2^{nd}	**%-unit**	**1.130**	2.6%	0.0%	0.0%	0.0%	0.0%	1.4%	**5.8%**	0.0%
Mastitis, 3^{rd}	**%-unit**	**1.437**	2.7%	0.0%	0.0%	0.0%	0.0%	1.4%	**5.7%**	0.0%
					OTHER DISEASES					
Metabolic, 1^{st}	**%-unit**	**0.672**	1.1%	0.0%	0.0%	0.0%	0.0%	2.0%	**6.9%**	0.0%
Metabolic, 2nd + 3^{rd}	**%-unit**	**1.210**	1.2%	0.0%	0.0%	0.0%	0.0%	1.9%	**6.8%**	0.0%
Feet&Legs, 1^{st}	**%-unit**	**0.684**	1.3%	0.0%	0.0%	0.0%	0.0%	2.3%	**6.3%**	0.0%
Feet&Legs, 2nd+3^{rd}	**%-unit**	**1.066**	1.6%	0.0%	0.0%	0.0%	0.0%	2.2%	**6.1%**	0.0%
E Repro, 1^{st}	**%-unit**	**0.765**	2.0%	0.0%	0.0%	0.0%	0.0%	1.6%	**6.3%**	0.0%
E Repro, 2nd+3^{rd}	**%-unit**	**1.229**	2.3%	0.0%	0.0%	0.0%	0.0%	1.5%	**6.0%**	0.0%
L Repro, 1^{st}	**%-unit**	**0.393**	0.0%	0.0%	0.0%	0.0%	0.0%	2.0%	**8.0%**	0.0%
L Repro, 2nd+3^{rd}	**%-unit**	**0.657**	0.0%	0.0%	0.0%	0.0%	0.0%	2.0%	**8.0%**	0.0%
					LONGEVITY					
Average, culling	**Day**	**0.522**	**7.1%**	-2.5%	**-5.7%**	0.0%	**-38.0%**	-0.2%	0.0%	-2.6%
					CONFORMATION					
Body	**Point**	**0.000**	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Udder	**Point**	**25.550**	0.0%	0.0%	0.0%	0.0%	0.0%	**10.0%**	0.0%	0.0%
Feet&Legs	**Point**	**17.033**	0.0%	0.0%	0.0%	0.0%	0.0%	**10.0%**	0.0%	0.0%
Milking speed	**Point**	**17.033**	0.0%	0.0%	0.0%	0.0%	0.0%	**10.0%**	0.0%	0.0%
Temper	**Point**	**8.517**	0.0%	0.0%	0.0%	0.0%	0.0%	**10.0%**	0.0%	0.0%

Table 7.2 RDC sensitivity analyses presented as % deviation from average.

		RDC average	Sales Value +10%	Feed costs +10%	Carcass Value +10%	Value of EUROP +10%	Heifer Value -50%	Labour Costs +10%	Vet. Costs +10%	AI + 20€ +100%
Alternative no.			**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
					MILK PRODUCTION					
Standard milk	**Kg**	**0.190**	**15.8%**	**-7.2%**	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
					BEEF PRODUCTION					
Net daily gain	**Kg/day**	**222.8**	0.0%	0.0%	29.1%	-0.9%	0.0%	0.0%	0.0%	0.0%
EUROP form score	**Score**	**13.6**	0.0%	0.0%	0.0%	**9.4%**	0.0%	0.0%	0.0%	0.0%
					CALVING TRAITS					
%stillborn, 1st	**%-unit**	**2.01**	0.0%	-0.7%	**9.7%**	-0.3%	**-37.0%**	-0.1%	0.0%	-2.4%
%stillborn, later	**%-unit**	**3.37**	0.0%	-0.7%	**9.1%**	-0.3%	**-39.2%**	-0.1%	0.0%	-2.6%
easy calvings, 1st	**Point**	**11.39**	0.2%	0.0%	0.0%	0.0%	0.0%	4.1%	**5.7%**	0.0%
easy, later	**Point**	**15.69**	0.2%	0.0%	0.0%	0.0%	0.0%	4.0%	**5.8%**	0.0%
					FEMALE FERTILITY					
Heifer, 1st to last AI	**Day**	**0.97**	0.0%	0.0%	-4.6%	0.0%	**-32.1%**	2.2%	0.0%	**36.0%**
Cows, calv. to 1st AI	**Day**	**0.56**	3.6%	-4.2%	12.3%	-0.3%	-71.6%	-2.4%	-2.3%	-20.1%
Cow, 1st to last AI	**Day**	**3.00**	0.7%	-0.8%	2.2%	0.0%	**-12.8%**	3.3%	-0.4%	**38.9%**
					MASTITIS					
Mastitis, -50d. 1st	**%-unit**	**1.456**	2.2%	0.0%	0.0%	0.0%	0.0%	1.5%	**6.1%**	0.0%
Mastitis, +50d, 1st	**%-unit**	**1.503**	2.2%	0.0%	0.0%	0.0%	0.0%	1.5%	**6.1%**	0.0%
Mastitis, 2nd	**%-unit**	**1.051**	2.4%	0.0%	0.0%	0.0%	0.0%	1.4%	**5.9%**	0.0%
Mastitis, 3rd	**%-unit**	**1.493**	2.5%	0.0%	0.0%	0.0%	0.0%	1.4%	**5.9%**	0.0%
					OTHER DISEASES					
Metabolic, 1st	**%-unit**	**0.671**	1.0%	0.0%	0.0%	0.0%	0.0%	2.0%	**7.0%**	0.0%
Metabolic, 2nd + 3rd	**%-unit**	**1.197**	1.1%	0.0%	0.0%	0.0%	0.0%	1.9%	**6.8%**	0.0%
Feet & legs, 1st	**%-unit**	**0.656**	1.3%	0.0%	0.0%	0.0%	0.0%	2.3%	**6.3%**	0.0%
Feet & legs, 2nd+3rd	**%-unit**	**1.045**	1.4%	0.0%	0.0%	0.0%	0.0%	2.3%	**6.2%**	0.0%
E Repro, 1st	**%-unit**	**0.716**	1.9%	0.0%	0.0%	0.0%	0.0%	1.6%	**6.4%**	0.0%
E Repro, 2nd+3rd	**%-unit**	**1.209**	2.1%	0.0%	0.0%	0.0%	0.0%	1.6%	**6.1%**	0.0%
L Repro, 1st	**%-unit**	**0.370**	0.0%	0.0%	0.0%	0.0%	0.0%	2.0%	**8.0%**	0.0%
L Repro, 2nd+3rd	**%-unit**	**0.670**	0.0%	0.0%	0.0%	0.0%	0.0%	2.0%	**8.0%**	0.0%
					LONGEVITY					
Average, culling	**Day**	**0.383**	**5.3%**	-1.6%	**-7.2%**	0.0%	**-46.0%**	-0.3%	-0.1%	-3.1%
					CONFORMATION					
Body	**Point**	**0.000**	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Udder	**Point**	**25.550**	0.0%	0.0%	0.0%	0.0%	0.0%	**10.0%**	0.0%	0.0%
Feet&Legs	**Point**	**17.033**	0.0%	0.0%	0.0%	0.0%	0.0%	**10.0%**	0.0%	0.0%
Milking speed	**Point**	**17.033**	0.0%	0.0%	0.0%	0.0%	0.0%	**10.0%**	0.0%	0.0%
Temper	**Point**	**8.517**	0.0%	0.0%	0.0%	0.0%	0.0%	**10.0%**	0.0%	0.0%

Table 7.3 Jersey sensitivity analyses presented as % deviation from average.

		Jersey average	Sales Value +10%	Feed costs +10%	Carcass Value +10%	Value of EUROP +10%	Heifer Value -50%	Labour Costs +10%	Vet. Costs +10%	AI + 20€ +100%
Alternative no.			**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
					MILK PRODUCTION					
Standard milk	**Kg**	**0.160**	**17.4%**	**-7.5%**	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
					BEEF PRODUCTION					
Net daily gain	**Kg/day**	**45.6**	0.0%	0.0%	**123.9%**	**-7.9%**	0.0%	0.0%	0.0%	0.0%
EUROP form score	**Score**	**10.1**	0.0%	0.0%	0.0%	**10.0%**	0.0%	0.0%	0.0%	0.0%
					CALVING TRAITS					
%stillborn, 1st	**%-unit**	**0.793**	0.0%	-0.5%	**11.8%**	-0.7%	**-90.7%**	-0.4%	0.0%	**-7.7%**
%stillborn, later	**%-unit**	**1.459**	0.0%	-0.5%	**12.8%**	-0.8%	**-89.5%**	-0.4%	0.0%	**-7.6%**
easy calvings, 1st	**Point**	**15.74**	0.2%	0.0%	0.0%	0.0%	0.0%	3.0%	**6.7%**	0.0%
easy, later	**Point**	**33.73**	0.3%	0.0%	0.0%	0.0%	0.0%	2.8%	**7.0%**	0.0%
					FEMALE FERTILITY					
Heifer Concept	**Day**	**1.26**	0.0%	-0.1%	-4.6%	0.0%	**-50.7%**	2.0%	0.0%	**28.9%**
ICF	**Day**	**0.28**	20.5%	-11.3%	14.8%	-1.0%	-131.5%	-5.4%	-5.6%	-43.5%
Cow concept. Rate	**Day**	**2.68**	2.1%	-1.2%	1.5%	-0.1%	**-13.6%**	4.0%	-0.6%	**43.9%**
					MASTITIS					
Mastitis, -50d. 1st	**%-unit**	**1.351**	2.3%	0.0%	0.0%	0.0%	0.0%	1.3%	**6.4%**	0.0%
Mastitis, +50d, 1st	**%-unit**	**1.351**	2.3%	0.0%	0.0%	0.0%	0.0%	1.3%	**6.4%**	0.0%
Mastitis, 2nd	**%-unit**	**1.009**	2.6%	0.0%	0.0%	0.0%	0.0%	1.3%	**6.2%**	0.0%
Mastitis, 3rd	**%-unit**	**1.748**	2.6%	0.0%	0.0%	0.0%	0.0%	1.3%	**6.1%**	0.0%
					OTHER DISEASES					
Metabolic, 1st	**%-unit**	**0.547**	1.1%	0.0%	0.0%	0.0%	0.0%	2.0%	**6.9%**	0.0%
Metabolic, 2nd + 3rd	**%-unit**	**1.156**	1.2%	0.0%	0.0%	0.0%	0.0%	2.0%	**6.8%**	0.0%
Feet & legs, 1st	**%-unit**	**0.577**	1.3%	0.0%	0.0%	0.0%	0.0%	2.4%	**6.3%**	0.0%
Feet&legs, 2nd + 3rd	**%-unit**	**1.109**	1.5%	0.0%	0.0%	0.0%	0.0%	2.3%	**6.2%**	0.0%
E Repro, 1st	**%-unit**	**0.641**	2.0%	0.0%	0.0%	0.0%	0.0%	1.5%	**6.6%**	0.0%
E Repro, 2nd+3rd	**%-unit**	**1.269**	2.2%	0.0%	0.0%	0.0%	0.0%	1.4%	**6.4%**	0.0%
L Repro, 1st	**%-unit**	**0.322**	0.0%	0.0%	0.0%	0.0%	0.0%	2.0%	**8.0%**	0.0%
L Repro, 2nd+3rd	**%-unit**	**0.619**	0.0%	0.0%	0.0%	0.0%	0.0%	2.0%	**8.0%**	0.0%
					LONGEVITY					
Average, culling	**Day**	**0.400**	**8.7%**	-3.0%	-3.8%	0.1%	**-31.3%**	-0.1%	0.2%	-1.9%
					CONFORMATION					
Body	**Point**	**0.000**	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Udder	**Point**	**25.550**	0.0%	0.0%	0.0%	0.0%	0.0%	**10.0%**	0.0%	0.0%
Feet&Legs	**Point**	**17.033**	0.0%	0.0%	0.0%	0.0%	0.0%	**10.0%**	0.0%	0.0%
Milking speed	**Point**	**17.033**	0.0%	0.0%	0.0%	0.0%	0.0%	**10.0%**	0.0%	0.0%
Temper	**Point**	**8.517**	0.0%	0.0%	0.0%	0.0%	0.0%	**10.0%**	0.0%	0.0%

8. Economic value of an index unit

In section 5 the proposals of the project group for relative weights were presented. They are summarized in table 8.1. Also, table 8.1 presents the relative weights decided by the NAV-board based on discussions within breeding organizations. The TMI using the approved weights is called NTM (Nordic Total Merit).

Table 8.1. Proposal for relative weights of the sub-indexes included in NAV-TMI based on economic analyses, and the final relative NTM weights decided by the NAV-board (unstandardized weights)

Trait	Economic proposal			Final NTM weights		
	Holstein	RDC	Jersey	Holstein	RDC	Jersey
Yield index	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**
Growth	**0.08**	**0.11**	**0.03**	**0.08**	**0.00**	**0.00**
Fertility	**0.41**	**0.28**	**0.23**	**0.41**	**0.28**	**0.30**
Birth index	**0.20**	**0.15**	**0.07**	**0.20**	**0.15**	**0.07**
Calving index	**0.22**	**0.13**	**0.06**	**0.22**	**0.13**	**0.07**
Udder health	**0.46**	**0.34**	**0.51**	**0.46**	**0.35**	**0.56**
Oth. diseases	**0.16**	**0.13**	**0.05**	**0.16**	**0.13**	**0.05**
Body	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
Feet & legs	**0.10**	**0.07**	**0.06**	**0.20**	**0.10**	**0.06**
Udder	**0.12**	**0.14**	**0.15**	**0.24**	**0.35**	**0.17**
Milk ability	**0.11**	**0.07**	**0.11**	**0.11**	**0.07**	**0.11**
Temperament	**0.04**	**0.03**	**0.03**	**0.04**	**0.03**	**0.03**
Longevity	**0.15**	**0.09**	**0.14**	**0.15**	**0.09**	**0.14**

The relative weights of sub indices for calculation of NTM are given in table 8.2. The relation between the final weights presented in table 8.1 and the weights presented in table 8.2 are determined by the standardization of the NTM.

8.1 The value of one unit of sub indices

The economic value per unit of each sub-index and of NTM is also given in table 8.2. These values are simply the product of the final relative weights in table 8.1 and the economic value of a unit of the yield index (see below).

The economic value of a unit of the yield index was shortly introduced in section 5. They were calculated from the economic values of yield trait presented in table 5.1-5.3 and from the relative weights given to kg of milk, fat and protein in yield index. Per unit of the yield index the value was:

- Holstein: 7.61 €
- RDC: 8.33 €
- Jersey: 6.00 €

Example: The economic value of an index unit for udder health in Holstein can therefore be calculated as 0.46 * 7.61 € = 3.50 €.

However, the value of an index unit for yield for Jersey was solely based on Danish assumptions on sales value of milk and costs, whereas the Holstein and RDC values are based on averages conditions in Denmark, Sweden and Finland. Both for Holstein and RDC the specific value for Denmark was generally lower than average. Therefore the Jersey value has been adjusted to "Nordic average level" by adding 0.79 €, such that the value used for a yield index unit within Jersey is 6.79 €. The 0.79 € was the average adjustment of the Danish values for Holstein and RDC.

8.2 The value of one unit of NTM

The economic value of the NTM depends on the standardization. The following relation exists: The value of NTM is the sum of economic values for the sub-indexes divided by the sum of index weights. Another way to calculate the value of NTM is to divide the economic value of a unit of the yield index by the factor used for standardization of the NTM

Table 8.2. Weights for calculation of the NTM index from sub-indexes, and the economic value per unit of the indexes.

Trait	Index weights for NTM			Economic value of an index unit, €		
	Holstein	**RDC**	**Jersey**	**Holstein**	**RDC**	**Jersey**
Yield index	**0.75**	**0.92**	**0.87**	**7.61**	**8.33**	**6.79**
Growth	**0.06**	**0.00**	**0.00**	**0.61**	**0.00**	**0.00**
Fertility	**0.31**	**0.26**	**0.26**	**3.12**	**2.33**	**2.04**
Birth index	**0.15**	**0.14**	**0.06**	**1.52**	**1.25**	**0.48**
Calving index	**0.17**	**0.12**	**0.06**	**1.67**	**1.08**	**0.48**
Udder health	**0.35**	**0.32**	**0.49**	**3.50**	**2.92**	**3.80**
Oth. Diseases	**0.12**	**0.12**	**0.04**	**1.22**	**1.08**	**0.34**
Body	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
Feet & legs	**0.15**	**0.09**	**0.05**	**1.52**	**0.83**	**0.41**
Udder	**0.18**	**0.32**	**0.15**	**1.83**	**2.92**	**1.15**
Milk ability	**0.08**	**0.06**	**0.10**	**0.84**	**0.58**	**0.75**
Temperament	**0.03**	**0.03**	**0.03**	**0.30**	**0.25**	**0.20**
Longevity	**0.11**	**0.08**	**0.12**	**1.14**	**0.75**	**0.95**
NTM	**-**	**-**	**-**	**10.15**	**9.05**	**7.80**

8.3 The economic values – definition

The economic values presented in table 8.2 represent the extra value per index unit created during the lifetime of an average animal.

The values in table 8.2 can be used to calculate the economic impact of different breeding schemes. But quite often we want to express the superiority of specific animals (often females).

When specific females are compared, it is practical to translate the results to values expressed in a heifer. This translation is shown in table 8.3. This translation is also valid for the value of NTM, except for Holstein where the economic value of the growth index is only expressed in bull calves.

Table 8.3. The economic value of NTM expressed in females.

	Holstein	RDC	Jersey
Yield index	**15.22**	**16.66**	**13.58**
Growth[1)]	**0**	**0**	**0**
Fertility	**6.24**	**4.66**	**4.07**
Birth index	**3.04**	**2.50**	**0.95**
Calving index	**3.35**	**2.17**	**0.95**
Udder health	**7.00**	**5.83**	**7.60**
Oth. Diseases	**2.44**	**2.17**	**0.68**
Body	**0.00**	**0.00**	**0.00**
Feet & legs	**3.04**	**1.67**	**0.81**
Udder	**3.65**	**5.83**	**2.31**
Milk ability	**1.67**	**1.17**	**1.49**
Temperament	**0.61**	**0.50**	**0.41**
Longevity	**2.28**	**1.50**	**1.90**
NTM,[2)]	**20.29**	**18.11**	**15.61**

1) *For Holstein bull calves the value of one unit of the growth index is 1.22 €. For all other indexes and breeds the index values expressed by bull calves are 0.*
2) *For Holstein where growth is a part of the NTM – this is only true if growth index is 100.*

In summary

The index value given in table 8.2 should be used if we want to express the total value of an average progeny. If we want to calculate the value of an index unit of the sire the value should be divided by 2 (assuming average dams).

If we want to express the value of a specific heifer we need to use the figures in table 8.3. As an example, we can compare two RDC heifers with a difference of 10 NTM units. The extra value of best heifer is 181.1 € (10*18.11 €).

If we want to express the value of a daughter group per daughter (per index unit in the daughter group) the figures in table 8.3 should be used. Using a Holstein bull, with an NTM index 10 units higher than another bull therefore results in offspring that on average has +5 NTM units. Then the economic merit is 101.45 € (5*20.29€) per daughter.

9. General discussion

This report on “Economic basis for a Nordic Total Merit Index” is a basis for the decision to be taken on a common Nordic breeding goal (NAV-TMI). The economic assumptions are based on the situation in spring 2007. The dramatic increase in feed prices and sales value of milk during 2007 was not included (sales value of milk seems to have dropped somewhat again). Ideally the economic assumptions should have reflected the situation 5 -15 years ahead when the selection decisions we make today will come into effect.

The work was carried out from the perspective of a dairy herd and only the economic aspects were included. All other factors of importance have been ignored. These factors could be:

- Animal welfare considerations
- Attitudes toward production systems both from the point of view of the producer, the consumer and the community
- Attitudes of breeders, breed organisation or AI-organisations (sales value of breeding stock)

Therefore a second step of this project is to assess future development for Nordic milk production both from an economic point of view, but it should also include all other aspects that might have an effect on future production.

9.1 Country differences

An important part of this second step is also to explore the possibilities of defining a common Nordic TMI. In this process country differences are important. **In general, the country differences are not large.**

In this comparison it is important to note that both for Holstein and RDC the value of milk production is higher in Finland than in Denmark and Sweden. This difference has an effect on the comparison of the other index weights when they are expressed relative to value of yield. Many index weights are lowest for Finland but most often this is due to the higher value of Finnish milk production and not because of a lower value of functional and conformation traits in Finland.

The Finnish milk prices used in this project include some subsidies. They will probably be phased out at some time in the future (except for the heavy subsidies for milk production in the Northern region). As a consequence, the Finnish index value will become even more similar to Danish and Swedish values.

9.2 Other results

In general, subsidies were not included, except for regional Finnish subsidies. In the Northern regions of Finland, the subsidies are very large. Results for the “Northern Finland” scenario have not been presented here, but of course, the large subsidies for milk production give a very large value of milk production relative to other traits.

At the outset, two different Swedish scenarios were defined, one for the “Milko” payment system and one for the “Arla” payment system, but the difference were insignificant.

Emphasis has been on the presentation of the value of total yield relative to the other traits, whereas the results on relative value of protein, fat and fluid milk were ignored.

The economic value of somatic cell count was evaluated in the model, but it turned out that the economic importance of this trait was insignificant. Therefore results on this trait were not presented.

9.3 Future development of the economic model

Presumably, there will be a demand for further analyses or revision of the economic basis of a Nordic TMI sometime in the future. Even though the current version of the model fulfilled the requirements of this project, there is certainly room for improvement. The following list points out some of the improvement that could be made.

The longevity complex: Improvement of most of the functional traits (fertility, health traits, conformation and yield) should decrease the need for culling of cows or should make it possible to change focus in selection. This has an economic value, but it is not included in the model and in the value of the traits. But the model gives an estimate of the value of decreasing culling rate (value of longevity). Because much of the improvement in longevity is really caused by improvement of other traits, much of the estimated value of longevity is transferred to other traits (as described in 4.8).

Lactation curve: The model of the lactation curve was used for the prediction of the value of yield, but also plays an important role for the estimation of the value of fertility, longevity and other traits. Currently, a Danish lactation curve model is used. For future work, it is important to replace the lactation curve model by a newer updated Nordic model.

Fixed costs: In the current set up, the economic value is based on the evaluation of variable costs of production. A more complete model should include all fixed costs as well (e.g. costs for housing and land requirements). This would make it possible to develop a more detailed evaluation and analysis of the economic values.

Value of fertility: The value of fertility turned out to be quite sensitive toward changes in the assumptions. For future use, both the modelling of fertility and the basic assumption should undergo a very careful analysis.

Conformation traits and milk ability: The assumptions used for estimating the value of conformation traits should be reviewed, and records from the new surveillance and milking systems will give us tools for a more accurate assessment of the economic value.

Basic assumption on biological level: For future work in this area, a detailed analysis of the biological assumption should be made. Some of the country differences observed might be due to some differences in recording procedures (e.g. differences in mortality of heifer and bull calves, differences in fertility and in frequency of diseases). This information is important for the estimation of breeding values, but also for the evaluation of economic values.

User interface: Even though the economic model is programmed in EXCEL, it is not an easy program to use and new project workers have to spend some time to get acquainted to the details of the program. Therefore, improvement of the user interface is an obvious task in the future development of this model.

10. References

Brascamp, E.W., Smith, C. & Guy, D.R. 1985. Derivation of economic weights from profit equations. Anim. Prod. 40:175-180.

Evans, R.D., P. Dillon, F. Buchley, D.P. Berry, M. Wallace, V. Ducrocq, and D.J. Garrick, 2006. Trends in milk production, calving rate and survival in 14 Irish dairy herds as a result of the introgression of Holstein- Friesian genes. Anim. Sci. 82:423-433.

Groen, A.F., 2001. Genetic improvement of livestock. Notes from NOVA-course, Uppsala, Sweden, June 2001. 107 pp.

Groen, A.F., Steine, T., Colleau, J.J., Pedersen, J., Pribyl, J., Reinsch, N. 1997. Economic values in dairy cattle breeding, with speciel reference to functional traits. Report of an EAAP-working group. Livest. Prod. Sci., 49:1-21.

Juga, J., Mäntysaari, E. A., Pösö, J., 1999. Economic response to total merit selection in Finnish Ayrshire breeding. Interbull Bulletin no. 23: 79-87.

Nielsen, H.M., 2004. Economic values for production and functional traits in dairy cattle breeding goals derived by stochastic simulation. Ph.D thesis, The Agricultural Universty, Copenhagen. 156 pp.

Olesen, I. Groen, A.F., and Gjerde, B. 2000. Definition of animal breeding goals for sustainable production systems. J. Anim. Sci. 78, 570-582.

Pedersen, J., Nielsen, U.S., Aamand, G.P., 2003. Economic values in the Danish total merit index. Interbull Bulletin No. 29:150-154.

Pedersen, J., Nielsen, U.S., Aamand, G.P., 2003. S-indeks for tyre af malke- og kombinationsracer, 2002. Report no 104. Danish Agricultural Centre, Danish Cattle. 39 pp.

Philipsson, J., Jansson, L., Brännäng, E., 1975. Selection index of bulls regarding economically important characters. Report of the Agricultural College of Sweden, Uppsala. Serie A 238.

VanRaden, P.M., Sanders, A.H., Tooker, M.E., Miller, R.H., Norman, H.D., Kuhn, M.T., Wiggans, G.R., 2004. Development of a national evaluation for cow fertility. J. Dairy Sci. 87:2285-2292.

Veerkamp, R.F., Emmans, G.C., Cromie, A.R., Simm, G., 1995. Variance components for residual feed intake in dairy cows. Livest. Prod. Sci. 41:111-120.

Østergaard, V., Neimann-Sørensen, 1989. Basis for chose of breeding goal and matching production system within dairy herds. Report no. 660 from the National Institute of Animal Science, Denmark. 157 pp.

Appendix A. The TMI-program

Manual
This is just a quick manual to get started. The name of the program must be TMI, if not the macros does not function properly.

Excel 1997
- Open TMI.xls
- In "Tools" select "macro"
- If you select "macros" again among the options given, you get a list of the macros currently developed in TMI-program.

Excel 2007 (do not change to 2007 format)
- Open TMI.xls
- In "Show" select "macro"
- Select “Show macro”
- If you select "macros" again among the options given, you get a list of the macros currently developed in TMI-program.

All traits groups all breeds and economic alternatives

Macro name	Desciption
ALL_TRAITS	Will run all the macros in sequence

The results are summed up in 3 sheets
- JER-comparisons: Compare Jersey with RDM and SDM-DH, and with previous Danish results
- RDC-comparison: Results for DNK, SWE and FIN main scenarios are shown together with the average values
- HOL-comparison: Results for DNK, SWE and FIN main scenarios are shown together with the average values.

Some color-conventions (not quite consequent)
- **Dark blue**: Text, explanations
- **Intensive blue**: Input, assumptions
- **Pink**: Results calculated from other results within this sheet
- **Red**: Results transferred from other sheet.

Per trait group: All breeds and economic alternatives
If more details for traits group are needed you can run one of the macros that are shown below. If one of these macros is run, a sheet with main results is shown (lower part of result sheet).

Macro name	Description
MILK_ALL	Milk production traits
SLAGT_ALL	Beef production traits
CALVING_ALL	Calving traits (due to maternal or direct genetic effects)
FERTILITY_ALL	Fertility traits
SCC_ALL	Somatic cell count
MASTITIS_ALL	Mastitis
OTHERD_ALL	Other diseases
CULLING_ALL	Longevity (via culling rate)
CONFMT_ALL	Conformation, Milking speed, Temperament
ALL_TRAITS	Will run all the preceding macros in sequence

Note: The macro **ALL_TRAITS** just run these 10 macros in sequence.

Per trait group, per breed and per economic alternative

If additional details for one trait group, **one breed and one economic alternative** are needed you can run one of the macros below (select breed and economic scenario at the top of the sheet BUDGET):

Macro name	Description
MILK	Milk production traits
SLAGT	Beef production traits
CALVING	Calving traits (due to maternal or direct genetic effects)
FERTILITY	Fertility traits
SCC	Somatic cell count
MASTITIS	Mastitis
OTHERD	Other diseases
CULLING	Longevity (via culling rate)
CONFMT	Conformation, Milking speed, Temperament

Note: The macro **MILK_ALL just run MILK** for all breeds and economic scenarios

Detailed results and differences

- Select breed and scenario at the top of the sheet BUDGET
- Save/print the results in **BUDGET** for a basic situation
- Change assumptions of a trait (e.g. 1st lactation 305d fat yield in **BASIC)**
- Save/print the results in **BUDGET** for the alternative
- Compare results.

Basic sheets

- **BUDGET**: Main program – only cell D2 and D4 should be varied.
  Eventually all cells in intensive blue can be varied – e.g. herd size in cell D6.
  - Cell D2: Breed (breed group) are set: (RDM = 1, SRB= 2, FAY= 3, DNK HOL = 6, SWE HOL = 7, FIN HOL = 8, JER = 10)
  - Cell D4: Economic assumptions: (SWE I = 1, DNK = 2, FIN I = 3, SWE II = 4, FIN II = 6)
  - Page 1: Mainly basic levels for the traits analyzed are listed – that is on this page the interaction with "macro"-sheets is made via the figures (gray) in column E
  - Page 2: More basic information – mostly consequences of the assumption made
  - Page 3: Results for cows
  - Page 4: Results for heifers
  - Page 5: Results for bull calves
  - Page 6: Summing up all results

- **BASIC**: The basic biological assumptions per breed – Via cell D2 in **BUDGET,** these assumptions are transferred to **BUDGET** and other sheets
- **ECONOMY**: The economical assumptions are defined in this sheet. They are transferred to the other sheets via Cell D4 in **BUDGET**
- **MILKPRICES:** Actual milk price is calculated depending on concentrations of fat and protein and quality (SCC). Besides the actual beef prices are calculated depending on carcass weight and form score
- **STILLB_CD:** Actual number of stillborn heifer and bull calves is calculated. Also number of difficult calvings with and without veterinary assistance is calculated
- **LACTATION** and **Lcurve305**: Calculate yield for 1st, 2nd and 3rd and later complete and incomplete lactations depending on level for 305-day production and days in milk (and calving age and calving interval)
- **FERTILITY**: Detailed calculation of fertility parameters for heifers and cows
- **DISEASES**: Detailed calculation of cost of stillbirth, calving difficulties, mastitis and other diseases (Not yet defined)
- **DISPOSAL:** Detailed calculation of effect of changing culling rate per lactation based on results from DISPOSAL1 and DISPOSAL2.
- **(DISPOSAL1, DISPOSAL2):** Ensure that overall replacement rate is kept constant when working with traits which influence the calving interval. In other cases they are inactive.
- **CONFORMATION**: Detailed calculation of effect of changing conformation
- **FEEDING**: The sheet where feed consumption is calculated
- **BULLS CALVES and BULL_YOUNG**: Growth and feed requirement for bull calves
- **HEIFER GROWTH** and **HEIFERS**: Growth and feed consumptions for heifers.

Sheets for analysis of total trait groups – and for all breeds

In the TMI there is number of additional sheets connected with automatic calculation of results. These sheets are all connected to macros. Table 1 gives a survey of the relationships.

Table A1. Sheets and macros for analysis of more traits and breeds

Basic sheet	Results sheet	Macros for Single Breed Single economy	Macros for All breeds All economies
Milk	MilkResults	MILK	MILK_ALL
calving	CalvingResults	CALVING	CALVING_ALL
Fert	FertilityResults	FERTILITY	FERTILITY_ALL
confmt	ConfmtResults	CONFMT	CONFMT_ALL
culling	CullingResults	CULLING	CULLING_ALL
Scc	SCCResults	SCC	SCC_ALL
mastitis	MastitisResults	MASTITIS	MASTITIS_ALL
Otherd	OtherdResults	METABOLIC	METABOLIC_ALL
Slagt	SlagtResults	BEEF	BEEF_ALL
-	-	-	TOTAL

Description of the calculations for a trait group (yield traits used as example)

- **Milk**: in this sheet the main results on milk are extracted from **BUDGET**. The assumptions are defined by the number in cell A5 (Breed and economy is defined in **BUDGET**)
  - 0 is the assumptions defined in BASIC
  - 1 defines a situation where 1st lactation milk is increased by 10%
  - 2 defines a situation where 2nd lactation milk is increased by 10%
  - 3 defines a situation where 3rd lactation milk is increased by 10%
  - 4 defines a situation where 1st lactation protein is increased by 10%

  - 5 defines a situation where 2nd lactation protein is increased by 10%
  - 6 defines a situation where 3rd lactation protein is increased by 10%
  - 7 defines a situation where 1st lactation fat is increased by 10%
  - 8 defines a situation where 2nd lactation fat is increased by 10%
  - 9 defines a situation where 3rd lactation fat is increased by10%
- **Macro MILK**. If this macro is activated these 10 situations are made in sequence and the results are transferred to the upper part of the sheet "**MilkResults**"
- **Macro MILK_ALL**. If this macro is activated the following action are invocated
  - In **BUDGET** the definition of breed and economy (cell D2 and D4) is defined
  - The **macro MILK** is started
  - In sheet **MilkResults** the final economic results are saved below
  - This procedure is repeated for 11 scenarios:
    - RDM and DNK economy
    - SRB and SWE I economy
    - SRB and SWE II economy
    - FAY and FIN I economy
    - FAY and FIN II economy
    - DNK HOL and DNK economy
    - SWE HOL and SWE I economy
    - SWE HOL and SWE II economy
    - FIN HOL and FIN I economy
    - FIN HOL and FIN II economy
    - JER and DNK economy

- At the end **Milk Results** contain an upper part with results on "JER and DNK economy". The lower part of **MilkResults** contains the economic results for all breed and economic situations.

For **calving**, **culling**, **scc**, **mastitis**, **fert** the procedure is exactly the same, except the number of traits are different.

The macro **ALL-TRAITS** is a macro that runs the macros**: MILK_ALL, CALVING_ALL, CULLING_ALL, SCC_ALL, CONFMT_ALL, MASTITIS_ALL, FERTILITY_ALL, OTHERD_ALL and SLAGT_ALL**

Detailed analysis of results

Detailed analyses of results are often needed in order to explain the results:
As previously described them most simple procedure is:

- Define the basic situation for breed and economy in BUDGET (Cell D2 and D4)
- Save/print the results in **BUDGET** for a basic situation.
- Change assumptions of a trait (eg 1st lactation 305d fat yield) in **BASIC**
- Save/print the results in **BUDGET**.
- Compare results.

The same is obtained by:

- Define the basic situation for breed and economy in BUDGET (Cell D2 and D4)
- Use one of the sheets **milk, calving, fert, confmt, culling, scc or mastitis** (**milk** is used as example)**:**
- Define trait 0 in A5.
- Save/print results from **milk**, eventually results from **BUDGET**

- Define the trait number to be analyzed in A5 of **milk** – that will change the level for the trait in question, normally by 10% (the change is shown in column E, page 1 in **BUDGET**)
- Save/print results from **milk**, eventually results from **BUDGET**
- Compare results.

Descriptions of procedures in the TMI-program

Production traits (yield)

In NAV nine production traits are evaluated: 305d milk, protein and fat each in 1st, 2nd and 3rd lactation:

- As economy does not depend on 305d days yield, but on lactation yield from both culled cows and cows with a subsequent lactation, a transformation of 305d production to lactation level is needed
- The economic evaluation must be able to evaluate change in each of these 9 traits without change in any of the other 8 traits.

The first of those 2 requirements is most easily obtained by using a lactation curve model

- At the start of the project the intension was to incorporate the fixed lactation curves from the NAV evaluation in the model
  - It would require some additional analyses and maybe some adjustments – e.g. seasonal effects should be modeled by test-season and not calving season
  - Incorporation of a completely new lactation curve model turned out to be a very comprehensive task

- Therefore it was decided to go on with the lactation curve model that existent in the current version of the TMI-program. The lactation curve program can be found in the sheet **LACTATION**. This model was built to meet the requirement of a repeatability program. The input for the program is:
  - Average 305d production at 1st lactation level
  - Average calving interval
  - Average age at 1st calving (= age at 1st AI + period 1st to last AI for heifers)
  - Average days in milk for culled cows (estimates from Nordic TD records)
  - Average days in milk for complete lactations (estimates from Nordic TD records)
  - Distribution of culled and staying cows – and the distribution of 1st, 2nd and later lactation (all these figures are calculated in the sheet DISPOSAL).

- To fulfill the second requirement (adapt the model to the multi-trait situation – where each trait is evaluated separately), it was necessary to make some corrections. They are made in the sheet **Lcurve305.** In this sheet a general correction is made (comparison of input 305d production level to the calculated 305d production), but especially the 2nd and 3rd (and later) level are adjusted to the levels given in the assumptions.

- In **LACTATION** the average yield of milk, protein and fat per year are calculated for 1st , 2nd and later lactation. The distribution of part lactation and complete lactations is taken into account. Also age at 1st calving has impact on the results (currently calving interval has no impact on yield). The results are then used for :
  - Calculation of milk price and income from milk production
  - Calculation of energy corrected milk, feed requirements and finally feed costs. According to our discussions protein yield should be taken into account as well.

Conformation traits
The calculations on culling are made in the sheet CONFORMATION. Conformation comprises 19 traits – In the genetic evaluation they are summarized 3 main conformation EBVs:

- Body
- Feet&Legs
- Udder.

The weights used to calculate breeding value for each of these three EBVs (Body, Feet&Legs, and Udder) from each of the linear traits has been set by the breed associations. The weights used can be found on NAVs homepage www.nordicebv.info

The task of the project groups is **not** to re-estimate these weights – but only to estimate economic importance of the main characters Body, Feet&Legs, and Udder relative to other traits in TMI.

Therefore the setup for this trait group is somewhat atypical compared to the other trait groups. The traits to be analyzed are a kind of phenotype for Body, Feet&Legs, and Udder.

The basic economic assumptions are made by (subjective) assessment of the extra work-load in an average herd. The current figures in the TMI program are the figures from the 2002 report on economic weights:

- Body: It does not have any impact on work if all traits included in "Body" were not more than one point away from the optimum on a linear scale
- Udder: If all traits included in "Udder" were linearly score more than one point away from the optimum, the extra work was assumed to be 15 minutes per day
- Fee &Legs: If all traits included in "Feet&Legs" were linearly score 1 point away from the optimum, the extra work was assumed to be 10 minutes per day.

For the two farmer-evaluated traits Milking Speed and Temper it is less complicated, because the recorded score can be evaluated directly.

- If the milking speed of all cows was one unit lower it was assumed that the extra work would be 10 minutes per day
- If the temperament of all cows was one unit lower it was assumed that the extra work would be 5 minutes per day.

Somatic cell count (SCC)
The calculations on SCC are made in the sheet MILKPRICE. Basically it calculates a correction to the milk price. There are (currently) two alternatives for this correction:

- Arla-system: Milk is subdivided in 5 classes according to level of SCC. For each class the basic milk price is regulated percent wise (currently +2% to -10%)
- Finnish system/Milko-system: Two classes are used. For herds with SCC-level above a certain limit 0.022 € (currently) are deducted per kg of milk.

In the current set up, SCC consist of different traits: SCC 1st lactation, SCC 2nd lactation, SCC 3rd lactation (and later), whereas deductions in milk price due to SCC levels are made on total herd production.

This is solved by calculation of the average herd SCC. Based on this average and a given standard deviation of herd averages – a distribution of herds on SCC-classes is calculated. Based on that distribution an average deduction in milk prices is determined.

Traits that are varied in the analyses

- Log_e(SCC/1000) in 1st lactation
- Log_e(SCC/1000) in 2nd lactation
- Log_e(SCC/1000) in 3rd and later

Fixed assumptions

- SD of herd log_e(SCC/1000) in 1st lactation
- SD of herd Log_e(SCC/1000) in 2nd lactation
- SD of herd Log_e(SCC/1000) in 3rd and later lactations

Calving traits

The Nordic evaluation of calving traits comprises

- Stillbirth at 1st and at later calvings – both as direct and as maternal trait
- Calving ease at 1st and at later calvings – both as direct and maternal trait
- Calf size at 1st and at later calvings – both as direct and as maternal trait – but intension was to use calf size as an extra information – and not as a trait of economic importance

In the assessment of economic value only the costs of stillbirth and calving difficulty are taken into account

- The cost of stillbirth is mostly lost income from raising heifers and bull calves but also from extra work and cost of destruction
- The cost of calving difficulty is mostly extra work and veterinarian cost related to the difficult calving, but **not** cost due to subsequent complications. It is assumed that subsequent complications will be accounted for in the evaluation of diseases.
- The difference in economic values of direct and maternal effects is not included at this stage (only discounting might create a difference).

The calculations take place in STILLB_CD. Besides, the largest effect of stillbirth is on number of heifers raised and number of bull calves produced. Therefore effect of stillbirth has an effect on many figures in the sheet, BUDGET.

Stillbirth

- Generally for all countries and breeds it is assumed that a stillborn calf requires extra work of 0.25 hours (15 minutes, note that extra work connected to a difficult calving is taken into accounted as well)
- In Finland extra 0.50 hours are added because it is common practice (and allowed) to bury stillborn calves, whereas costs of destruction of stillborn calves are not included in Finland
- In the current model: If stillbirth rate is increased by 10% the change in number of stillborn heifer and bull calves are quite different, in case there is a large difference stillbirth rate for heifer calves and bull calves.
- It was pointed out that work related to feeding and raising calves might be included as variable costs (the consequences would be lower value of stillbirth because these costs are saved for stillborn calves – probably, the work related to feeding new born calves is the most important factor).

Calving difficulty

- When the percentage of difficult calvings is changed it assumed a proportional change in percent difficult with veterinarian and without veterinarian assistance
- It is assumed that 20% of difficult calvings with veterinarian assistance require a caesarean or dissections (higher cost). The same figure is used across countries and breeds
- A “normal” difficult calving require extra 1.5 hours work from the herdsman
- Caesareans and dissections require extra 3.0 hours work from the herdsman

Longevity (Culling rates)
The calculations on culling are made in the sheet DISPOSAL (it is taken from a program on economics for sexed semen made by Jehan Ettama). The basic input consists of traits that are varied in the analyses

- % culled in 1st lactation
- % culled in 2nd lactation
- % culled in 3rd and later lactation (per lactation).

Fixed assumptions
Note that fertility has an impact in this calculation – such that fertility has an indirect impact on longevity.

- Calving interval
- Days in milk for culled cows.

What happens in this sheet?

- An iteration of 20 rounds is started (20 round are enough to obtain stable results)
- Start will 1000 1st lactation cows
- The assumptions on culling rates
- The assumption on calving interval and days in milk for culled cows.

Results:
At the end of the iteration a distribution of cows per lactation is given. From that

- The number of culled cows are calculated
- The number of survived cows is given
- From that a series of results is calculated – most important average culling rate and longevity
- The results are transferred to other sheets of the TMI program. They have an impact on total production and number of calves born per year – and number of heifer required for replacement.

In the current set up, there is an interaction between fertility and longevity, because the calving interval is one of the assumptions used for calculating longevity. It is a one-way relationship, because changing culling rates does not have effect on fertility (this is discussed further in the section on Fertility). This trait is expected to come out with a relatively high economic value. It is planned to transfer as much weight as possible to the other traits in TMI. This transfer will be based on analyses of the relationship between longevity and the other traits in TMI.

Fertility traits
The fertility traits currently evaluated in NAV are
(Traits in italics are not included in the total fertility index – but used as information traits, only)

- Heifer IFL Interval from 1st to last AI
- Heifer AIS Number of inseminations
- Heifer NNR Non-return rate at 56 days
- Heifer HST Heat strength (observed in Sweden only)
- Cow ICF Interval from calving to 1st insemination
- Cow IFL Interval from 1st to last AI
- Cow AIS Number of inseminations
- Cow NNR Non-return rate at 56 days
- Cow HS Heat strength (observed in Sweden only)
- Cow FRT Fertility treatments

Fertility treatments are totally confounded with "reproductive diseases". The economic evaluation of reproductive diseases is described later. Therefore the TMI program focuses on the evaluation of economic value of: IFL and AIS for heifers and cows and ICF for cows. IFL and AIS are highly correlated (i.e. they are nearly the same trait – therefore the economic value can be assigned to either one or the other of the traits – or be distributed freely between them).

Economic value of AIS and IFL

In the TMI program the calculation of fertility has two basic assumptions:

- Conception rate(CR): The chance of a heifer or cow to become pregnant after an AI
- Rate of inseminated heifers or cows (IR). The not-inseminated cows are the sum of not-observed heats and cows not having heats in regular 21 days intervals – due to disease – or "whatever" reason.

The method is to simulate an insemination sequence up to a maximum number of inseminations (potential inseminations = number of heats).

- The simulations start with
  - All heifers are inseminated at the average age at 1st insemination (specific per country and breed)
  - All cows are inseminated at the average ICF (specific per country and breed)
- Then the simulation continues heat by heat (coming regularly in 21 day intervals) calculating
  - Average number pregnant animals
  - Average number non-pregnant animals
  - Average number inseminated animals
  - Average number not inseminated animals
- At a specified heat (potential AI) the simulation is stopped – and the total results are summarized by:
  - Average number of potential AI, equal to number of heat observations the herdsman must make. This result is the basis for calculating the work related to heat detection
  - Average number of AI
  - Average IFL
  - Percent pregnant animals at the end of the simulation
- The procedure is made separately for heifers and for cows.

The economic consequences are expressed via:

- Change in calving interval – this has an effect on yearly production per cow and in the current setup on average culling rate (number culled relative to number cows)
- Cost of AI – and work related to AI
- Cost of work related to heat detection.

In the program, changes in fertility are made by changing conception rate (or rate of cow not inseminated). The economic values will be expressed per unit of change in AIS or IFL.

Economic value of ICF

- The calculation of ICF is very simple. Changing ICF will change the calving interval. Changing the calving interval has an effect on yearly production per cow and in the current set up on average culling rate (number culled relative to number cows).

Another important relationship exists between fertility and yield.

- Fertility has an impact through the effect of pregnancy on yield. From the yield evaluation model we known that it starts around 120 days after conception and that pregnancy will decrease milk yield with around 4-6 kg milk per day on average (Holstein and RDC).

- Another question is, whether a shorter calving interval will shorten days in milk (DIM) or days dry. In out basic assumptions, the average days dry are longer than the recommended 45-50 days. Therefore it is assumed that a shorter calving interval will reduce average day's dry and not average days in milk.

Udder health traits

The udder health traits currently evaluated in NAV are

- Udder diseases before 50 days in 1st lactation as binary trait
- Udder diseases 50-305 days in 1st lactation as binary trait
- Udder diseases before 305 days in 2nd lactation as binary trait
- Udder diseases before 305 days in 3rd lactation as binary trait.

Besides, somatic cell score and a number of conformation traits are included as information traits, but only these 4 traits are included in the index for udder health.

In the economic evaluation of udder health the importance is related to the total number of cases, and not to the occurrence measured as a binary trait. Therefore the relationship between those two figures must be known.

Input to the calculation is the average of the traits evaluated and the corresponding total number of cases. It is assumed that a change in the evaluation trait will change the total number of cases proportionately.

The cost related to udder health currently includes:

- Cost of veterinarian treatment
- Extra work for the herdsman
- Amount of milk discarded due to treatment with antibiotics, hormones etc.

Metabolic diseases

The metabolic diseases that are planned to be evaluated in NAV are:

- Metabolic disease before 305 days in 1st lactation as binary trait
- Metabolic disease before 305 days in 2nd lactation as binary trait
- Metabolic disease before 305 days in 3rd lactation as binary trait.

In the economic evaluation of metabolic diseases the importance is related to the total number of cases, and not to the occurrence measured as a binary trait. Therefore the relationship between those two figures must be known.

Input to the calculation is the average of the traits evaluated and corresponding number of cases. It is assumed that a change in the evaluation trait will change the total number of cases proportionately.

The cost related to metabolic diseases currently included:

- Cost of veterinarian treatment
- Extra work for the herdsman
- Amount of milk discarded due to treatment with antibiotics, hormones etc.

Feet&Legs diseases

The Feet&Legs diseases that are planned to be evaluated in NAV are:

- Feet&Legs disease before 305 days in 1st lactation as binary trait
- Fee &Legs disease before 305 days in 2nd lactation as binary trait
- Feet&Legs disease before 305 days in 3rd lactation as binary trait.

In the economic evaluation of feet & leg diseases the importance is related to the total number of cases, and not to the occurrence measured as a binary trait. Therefore the relationship between those two figures must be known.

Input to the calculation is the average of the traits evaluated and corresponding number of cases. It is assumed that a change in the evaluation trait will change the total number of cases proportionately.

The cost related to Feet&Legs diseases currently includes:

- Cost of veterinarian treatment
- Extra work for the herdsman
- Amount of milk discarded due to treatment with antibiotics, hormones etc.

Early reproductive diseases

The reproductive diseases that are planned to be evaluated in NAV are:

- Reproductive disease before 40 days in 1st lactation as binary trait
- Reproductive disease before 40 days in 2nd lactation as binary trait
- Reproductive disease before 40 days in 3rd lactation as binary trait.

In the economic evaluation of reproductive diseases the importance is related to the total number of cases, and not to the occurrence measured as a binary trait. Therefore the relationship between those two figures must be known.

Input to the calculation is the average of the traits evaluated and corresponding number of cases. It is assumed that a change in the evaluation trait will change the total number of cases proportionately.

The cost related to reproductive diseases currently includes:

- Cost of veterinarian treatment
- Extra work for the herdsman
- Amount of milk discarded due to treatment with antibiotics, hormones etc.

Late reproductive diseases

The reproductive diseases that are planned to be evaluated in NAV are:

- Reproductive disease before 40 days in 1st lactation as binary trait
- Reproductive disease before 40 days in 2nd lactation as binary trait
- Reproductive disease before 40 days in 3rd lactation as binary trait.

In the economic evaluation of reproductive diseases the importance is related to the total number of cases, and not to the occurrence measured as a binary trait. Therefore the relationship between those two figures must be known.

Input to the calculation is the average of the traits evaluated and corresponding number of cases. It is assumed that a change in the evaluation trait will change the total number of cases proportionately

The cost related to reproductive diseases currently includes:

- Cost of veterinarian treatment
- Extra work for the herdsman
- Amount of milk discarded due to treatment with antibiotics, hormones etc.

Beef production traits

Beef production traits that are evaluated in Sweden and Denmark are

- Net daily gain calculated as carcass weight / age at slaughter (bull calves only)
- EUROP form score of bull calves only.

The beef production of dairy breed varies slightly in the three countries

- FIN: Almost all bull calved are transferred to specialised beef-production herds. The bull calves are slaughtered at a relatively high age and slaughter weight (300-400 kg)
- SWE: Almost all bull calves are transferred to specialised beef-production herd. The bull calves are slaughtered at a relatively high age and slaughter weight (300-400 kg)
- DNK (RDM and SDM): Around one third of the bull calves are transferred to specialised beef-production herds. The bull's calves are either slaughtered at a carcass weight below 200 kg – or at a carcass weight around 250 kg. The distribution of those two categories is around fifty-fifty
- DNK (Jersey). In practice, a major part of all Jersey bull calves are culled at birth. The remaining calves are slaughtered at a weight around 200 kg. When calculating the value of beef production, all bull calves are assumed to be raised and slaughtered.

The economic effect of growth rate is calculated in two sheets (BULLCALVES or BULL_YOUNG) in order to be able to take into account a mixed production of young and older bull calves.

The price regulations according to EUROP-score have been converted to a linear scale.