Economic Breeding Index for Dairy Cattle in Ireland

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D.P. Berry[1*], L.Shalloo[1], A.R. Cromie[2], V.E. Olori[2] and P. Amer[3]

[1] *Dairy Production Department, Teagasc, Moorepark Production Research Center, Fermoy, Co. Cork, Ireland.*

[2] *Irish Cattle Breeding Federation Society Ltd., Shinagh House, Bandon, Co. Cork, Ireland.*

[3] *Abacus Biotech Limited, P.O. Box 5585, Dunedin, New Zealand.*

* Corresponding Author: Donagh P. Berry, Dairy Production Department, Teagasc, Moorepark Production Research Center, Fermoy, Co. Cork, Ireland. Tel: 003532542222; Fax: 003532542340; E-mail: dberry@moorepark.teagasc.ie

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Executive Summary

- Economic values and cumulative discounted expressions were used to calculate the optimal economic weighting on milk production, fertility, calving and beef performance traits within the economic breeding index (EBI) for dairy sires in Ireland

- The economic effect of a 1% change in the proportion of cows requiring severe calving assistance or worse was -€3.25 per cow calving not including calf mortality. When the costs associated with reduced milk production and impaired reproduction are not included, the economic value of calving difficulty was -€1.31. This reduced value avoids double counting when considering a sire's genetic effects of calving difficulty on his female descendants and their calves. Any effects on milk yield and reproduction on descendants should be accounted for in the sire's breeding value for milk yield and survival. There is no issue of double counting when considering the effects of the genes of his own calves on the cows he is mated to.

- The economic value for gestation length is synonymous with the economic value for calving interval (-€7.09) under the assumption that there is a genetic regression of one for calving interval on gestation length. So as to avoid double counting with calving interval, economic effects of gestation length were only accounted for when considering expressions of the genes of a sire's own calves on the cows he is mated to.

- The economic value for calf mortality is the price of a black and white calf weighted by the probability the dead calf is male or female. The economic effect of a 1% change in calf mortality in Ireland is -€1.94.

- The economic value for cull cow carcase weight is a function of cow carcase value (including a decrease in the proportion of animals receiving penalised carcase prices as average carcase weight increases), maintenance cost and increased cost of growing. The economic weight (i.e., summation across the three parameters and their associated discounted expressions) for carcase weight is €0.04.

- Surplus calf carcase value is described using three parameters: carcase weight, carcase conformation score and carcase fat score. The economic value for carcase weight, carcase conformation score and carcase fat score is €1.22, €5.24 and -€8.19, respectively.

- Cumulative discounted expressions (CDE) were computed using an elaborate model accounting for the many pathways of gene expressions for a dairy sire within both dairy and beef herds. A complete description of the CDE model is currently being prepared for scientific publication. Economic values were multiplied by the appropriate CDE to derive the economic weights for inclusion in the EBI.

- The traits, economic values, cumulative discounted genetic expressions, economic weights and relative emphasis are summarised below

Sub-index	Trait	Economic value	CDE	Economic weight	Genetic SD	Relative emphasis
Production	Milk	-0.076	1	-0.076	446	-14%
	Fat	1.5	1	1.5	16.64	10%
	Protein	5.22	1	5.22	13.11	28%
Fertility	Calving interval	-7.09	1	-7.09	6.58	-19%
	Survival	10.77	1	10.77	3.6	16%
Calving	Calving difficulty direct – matings	-3.25	0.63			
	Calving difficulty direct – descendants	-1.31	0.7			
	Calving difficulty direct TOTAL			-2.96	2.84	-3%
	Calving difficulty maternal	-1.31	1.13	-1.48	1.13	-1%
	Gestation	-7.09	0.63	-4.47	1.68	-3%
	Calf mortality	-1.94	1.33	-2.58	0.94	-1%
Cull cow	Cull cow - salvage carcase value	3.00	0.24			
	Cull cow - feed intake	-0.37	1			
	Cull cow - heifer feed	-0.88	0.35			
	Cull cow TOTAL			0.04	13.92	0.2%
Calf Carcase	Carcase weight	1.22	0.75	0.92	9.05	3%
	Carcase conformation	5.24	0.75	3.93	0.51	1%
	Carcase fat	-8.19	0.75	-6.14	0.41	-1%

- Little effect was observed on both EBI or sire ranking on EBI across the alternative proposed indexes; correlations between indexes were all greater than 0.95

- The relative emphasis on production:non-production traits following inclusion of calving and beef performance in the index is 49:51.

- The response to selection in milk production is expected to increased with the inclusion of calving and beef performance in the EBI attributable mainly to the positive correlations observed in sire PTAs between beef performance and milk production and the positive economic weight on beef performance. This effect is also enhanced by moderate unfavourable relationships for calving performance and survival with the beef performance sub-index.

- It is therefore recommended to simultaneously include both calving and beef performance in the revised EBI (in addition to milk production and fertility) to account for any antagonistic correlations between the calving and beef performance sub-indexes. The correlation between the calving and beef performance sub-index in a sample of sires available in Ireland was –0.12.

- Failure to select for calving and beef performance simultaneous with milk production and fertility will cost the industry over €1.6 m/yr after ten years of selection or will result in a reduction in genetic gain for overall profitability of 3% per annum

Background

The economic breeding index (EBI) was launched in November 2000 as the selection tool for the realization of the Irish dairy breeding objective. It is derived from the breeding values of three milk production traits namely milk yield, fat yield, protein yield, as well as two functional traits measuring cow fertility (calving interval) and longevity in the herd (survival) each weighted by their respective economic values.

Estimated breeding values (EBVs) are currently being estimated by the Dutch consortium, lead by Roel Veerkamp, for milk production, fertility, calving performance and beef performance traits, among others. Selection index methodology is used to select on all traits affecting animal profitability, each optimally weighted by their economic value. Failure to include traits of economic importance in a national breeding objective may lead to unfavourable genetic trends if the excluded traits are antagonistically correlated with traits under direct selection.

Veerkamp *et al*. (2002) described the economic breeding index (EBI) in great detail outlining the derivation of the economic values for milk yield, fat yield, protein yield, calving interval and survival. These economic values were subsequently updated (Berry *et al*., 2004) and are summarised in the current report. Amer *et al*. (2001) has described the derivation of breeding objectives for beef cattle in Ireland, including consideration of both direct and maternal calving ease, gestation length, and beef performance. Calving performance traits (i.e., calving difficulty, gestation length, calf mortality) as well as beef performance traits (i.e., carcase weight, carcase conformation, carcase fat score) are additional considerations for inclusion in the EBI.

The economic values per unit trait change for direct and maternal traits are identical. However, a differential in economic weight between the two trait definitions may arise from differences in the rate and timing of direct expressions compared with maternal expressions. A further complication arises in multiple trait breeding objectives, where double-counting of the effects on traits already included in the breeding objective must be avoided.

The objective of the present report is to summarise the development of the EBI to date and to describe how additional traits (i.e., calving difficulty, gestation length, calf mortality, carcase weight, carcase conformation and carcase fat score) could be included in the calculation of the EBI and to summarise the consequences for sire rankings and response to selection.

Inclusion of calving and beef performance traits in the economic breeding index

Currently, the economic weights for traits included in the EBI are on a per lactation basis. In order, to avoid further changes in economic weightings in the EBI it is proposed to continue the definition of the EBI on a per lactation basis. This is why the CDE reported by Berry et al. (2005) are scaled down by the CDE of annual cow traits under complete market failure (i.e., 1.58) The proposed economic weights and relative emphases on traits included in the proposed EBI under two scenarios of zero market failure or complete market failure are summarised in Table 1 and 2, respectively.

The relative emphasis on traits included in the proposed EBI under two scenarios of zero market failure or complete market failure are also summarised in Tables 1 and 2, respectively. Traditionally relative emphases within selection indexes were derived from the product of the genetic standard deviation and the economic weight as a proportion of the sum across all traits. Genetic standard deviations were those obtained from a sample of sire breeding values in Ireland. However, such calculations ignore the existence of favourable or antagonistic correlations among the product of the traits and economic weights. Thus, relative emphasis was also calculated using a multiple regression (Roughsedge et al., 2005) with EBI as the dependent variable and each of its component traits as the independent variable. The percentage contribution to variation of the EBI was calculated as the Type III sums of squares for each trait as a percentage of the total sums of squares. Relative emphasis calculated using this procedure are include din Tables 1 and 2 in parenthesis.

Comparison of Tables 1 and 2 reveal only minor differences in economic weights and relative emphasis under zero or complete market failure. Thus, accounting for expression of dairy sires' genes in suckler herds by their dairy-beef crossbred daughters will have minimal impact on sire rankings.

The relative emphasis on calving difficulty (~4%) is in close agreement with the relative emphasis in the breeding objectives of Denmark (6%), The Netherlands (8%) and the USA (4%) (Miglior, 2004). The relative emphasis on the subindexes within the current and proposed EBI is illustrated in Table 3 across the alternative EBI definitions. Minimal differences existed in relative weighting between the two market failure scenarios. Under zero market failure, when all traits are included in the EBI, the ratio of relative emphasis on production:non-production traits is 51:49. The relative emphasis on milk production in the proposed EBI is similar to the emphasis on the old TOP index in the UK as well as the RZG in Germany and the ISU in France (Miglior, 2004).

Table 1. *Economic weights (EW) and relative emphasis on the various traits across three proposed possible modifications to the economic breeding index under zero market failure. Relative emphasis calculated using multiple regression are included within parenthesis.*

Trait	Genetic SD	EW	Relative emphasis		
			Current EBI	EBI with calving	EBI with calving and beef
Milk (kg)	446	-0.08	-17% (-11%)	-14% (-10%)	-14% (-9%)
Fat (kg)	16.64	1.50	12% (11%)	11% (10%)	10% (11%)
Protein (kg)	13.11	5.22	32% (32%)	29% (31%)	28% (30%)
Calving interval (days)	6.58	-7.09	-22% (-27%)	-20% (-26%)	-19% (-26%)
Survival (%)	3.6	10.77	18% (19%)	16% (18%)	16% (18%)
Direct calving difficulty (%)	2.84	-2.96		-4% (-2%)	-3% (-2%)
Maternal calving difficulty (%)	1.13	-1.48		-1% (-0%)	-1% (-0%)
Gestation length (days)	1.68	-4.47		-3% (-2%)	-3% (-2%)
Direct calf mortality (%)	0.94	-2.58		-1% (-0%)	-1% (-0%)
Cow carcase weight (kg)	14	0.04			0.2% (0%)
Calf carcase weight (kg)	9	0.92			3% (1%)
Calf carcase conformation	0.51	3.93			1% (0.1%)
Calf carcase fat score	0.41	-6.14			-1% (-0.1%)
			100.0%	100.0%	100.0%

Table 2. *Economic weights (EW) and relative emphasis on the various traits across three proposed possible modifications to the economic breeding index under complete market failure. Relative emphasis calculated using multiple regression are included within parenthesis.*

Trait	Genetic SD	EW	Relative emphasis		
			Current EBI	EBI with calving	EBI with calving and beef
Milk (kg)	446	-0.08	-17% (-11%)	-15% (-10%)	-14% (-9%)
Fat (kg)	16.64	1.50	12% (11%)	11% (10%)	10% (11%)
Protein (kg)	13.11	5.22	32% (32%)	30% (31%)	28% (31%)
Calving interval (days)	6.58	-7.09	-22% (-27%)	-20% (-26%)	-19% (-26%)
Survival (%)	3.6	10.77	18% (19%)	17% (18%)	16% (18%)
Direct calving difficulty (%)	2.84	-2.79		-3% (-2%)	-3% (-2%)
Maternal calving difficulty (%)	1.13	-1.31		-1% (-0%)	-1% (-0%)
Gestation length (days)	1.68	-4.47		-3% (-2%)	-3% (-2%)
Direct calf mortality (%)	0.94	-2.33		-1% (-0%)	-1% (-0%)
Cow carcase weight (kg)	14	0.04			0% (0%)
Calf carcase weight (kg)	9	0.83			3% (1%)
Calf carcase conformation	0.51	3.56			1% (0%)
Calf carcase fat score	0.41	-5.57			-1% (-0%)
			100.0%	100.0%	100.0%

Table 3. *Relative emphasis on sub-indexes within the current and alternative EBI under zero market failure. Relative emphasis calculated using multiple regression are included within parenthesis.*

Index	$EBI_{CURRENT}$	EBI_{CALV}	EBI_{CALV_BEEF}
Production	60% (54%)	55% (51%)	52% (51%)
Fertility	40% (46%)	37% (44%)	35% (44%)
Calving		11% (4%)	8% (4%)
Cull cow carcase wt			0% (0%)
Calf carcase			5% (1%)

Sub-indexes

Table 4 summarises the relative emphasis of traits within the various sub-indexes. Protein contributes most to the variation in the production index; similar calving interval is most influential on the fertility index. Both direct calving difficulty and gestation length have a large effect on the calving sub-index while surplus calf carcase weight clearly has the strongest influence on the beef sub-index value of an animal.

Table 4. *Relative emphasis of traits within sub-indexes under zero market failure. Relative emphasis calculated using multiple regression are included within parenthesis.*

Trait/Sub-index	**Production**	**Fertility**	**Calving**	**Beef**
Milk (kg)	27% (23%)			
Fat (kg)	20% (20%)			
Protein (kg)	54% (58%)			
Calving interval (days)		55% (69%)		
Survival (%)		45% (30%)		
Direct calving difficulty (%)			41% (42%)	
Maternal calving difficulty (%)			10% (2%)	
Gestation length (days)			37% (50%)	
Direct calf mortality (%)			12% (6%)	
Cow carcase weight (kg)				4% (0.1%)
Calf carcase weight (kg)				62% (85%)
Calf carcase conformation				15% (8%)
Calf carcase fat score				19% (7%)

Effect of inclusion of additional traits on sire rankings

Estimated breeding values for production, fertility, calving and beef performance traits from the 2004 December proof run were used. In total 1,437 black and white sires were available with a reliability for the current EBI of greater than 50%.

Correlations were calculated between sire rankings on the current EBI and sire rankings on the current EBI including calving related traits (EBI_{CALV}), beef-related traits (EBI_{BEEF}), or calving and beef-related traits (EBI_{CALV_BEEF}). Spearman and Pearson correlations between the alternative indexes are summarised in Table 5. All correlations with the current EBI were greater than 0.96. Thus, on average minimal changes in sire EBI and sire ranking on EBI is expected. This is an average and some sires may fluctuate considerably.

Table 5. *Pearson (above diagonal) and Spearman (below diagonal) correlations among the current EBI ($EBI_{CURRENT}$) and the current EBI including calving related traits (EBI_{CALV}), beef-related traits (EBI_{BEEF}), or calving and beef-related traits (EBI_{CALV_BEEF}).*

Index	$EBI_{CURRENT}$	EBI_{CALV}	EBI_{BEEF}	EBI_{CALV_BEEF}
$EBI_{CURRENT}$	1.000	0.981	0.990	0.975
EBI_{CALV}	0.980	1.000	0.967	0.990
EBI_{BEEF}	0.988	0.966	1.000	0.981
EBI_{CALV_BEEF}	0.973	0.990	0.981	1.000

Response to selection under alternative economic breeding indexes

Response to selection was calculated by sorting sires, with information on all traits in the proposed EBI, on the alternative indexes and extracting out the top 38% (average of selected group is 1 standard deviation above the mean) of sires ranked on each index separately. Expected genetic trend in EBI was assumed to be equivalent to the past genetic trend of individual animal genetic merit of €5.2/yr (ICBF, 2004); this is likely to be a conservative estimate of the genetic trend if future selection of progeny test sires are based on EBI. Genetic trend over the next ten years was predicted using each of the alternative indexes. The genetic change expected (in breeding values), given previous EBI trends, are summarised in Table 6 for the alternative indexes.

It is important to remember that the genetic progress reported in Table 6 reflects a genetic gain of €5.2/yr. The ICBF statistics (ICBF, 2004) suggests a five fold increase in genetic gain is achievable with a national progeny testing scheme of 100 sires. Under such circumstances, the figures reported in Table 6 should be multiplied by five.

Table 6. *Expected genetic gain in individual animal genetic merit after ten years of selection based on a genetic gain of €5.20/yr.*

Trait / Index	$EBI_{CURRENT}$	EBI_{CALV}	EBI_{BEEF}	EBI_{CALV_BEEF}
$EBI_{CURRENT}$ (€)	51.79	50.88	50.85	50.50
EBI_{CALV} (€)	54.47	55.46	52.99	54.83
EBI_{BEEF} (€)	51.67	50.61	52.35	51.44
EBI_{CALV_BEEF} (€)	54.34	55.19	54.49	55.77
Production index	23.35	23.02	26.03	23.87
Fertility index	28.45	27.86	24.82	26.63
Calving index	2.67	4.58	2.15	4.33
Beef index	-0.13	-0.27	1.50	0.94
Milk (kg)	-1.48	-10.59	13.69	1.26
Fat (kg)	4.62	4.43	5.07	4.57
Protein (kg)	3.12	2.98	3.73	3.28
Calving interval (d)	-2.22	-2.16	-1.95	-2.08
Survival (%)	1.18	1.16	1.02	1.10
Direct calving difficulty (%)	-0.61	-0.93	-0.44	-0.81
Maternal calving difficulty (%)	0.12	0.19	0.08	0.16
Gestation (d)	-0.21	-0.44	-0.19	-0.44
Calf mortality (%)	-0.06	-0.08	-0.05	-0.09
Cow carcase weight (kg)	-0.96	-1.56	0.84	-0.01
Calf carcase weight (kg)	-0.08	-0.22	1.42	0.94
Calf carcase conformation	0.03	0.06	0.01	0.03
Calf carcase fat score	0.02	0.04	-0.02	0.01

Results in Table 6 indicate an expected increased response in milk production when both the calving sub-index and the beef performance sub-index are included in the overall EBI. This is attributed mainly to the positive correlation between sire PTAs for cull cow/calf carcase weight and milk production coupled with the positive economic weight on carase weight. Liinamo et al. (2001) also reported positive genetic correlations between carcase weight in bulls and milk production in heifer relatives in a Finnish Ayrshire sample population. Liinamo and van Arendonk (1999) concluded that including carcase traits in breeding decisions does not greatly affect genetic response in milk production while it may increase profits in the beef producing sector.

Table 6 also illustrates a reduction in the improvement in fertility when selecting on beef performance simultaneous with milk production, fertility and calving performance. This is attributable mainly to the antagonistic genetic correlations between carcase weight and fertility and the positive economic weight on carcase weight. If only the beef performance sub-index was added to the current EBI then the favourable trend in direct calving difficulty, gestation length and calf mortality would deteriorate. This is due to a mild antagonism between carcase PTAs and calving PTAs

Assuming the EBI including calving performance and beef performance (simultaneous with milk and fertility performance) is a true indicator of a sire's economic breeding index then selection on the current EBI will fall €1.43/lactation short of selection on the overall proposed EBI after 10 years. When accumulated across the national dairy herd of approx. 1.15 million this equates to over €1.6 million/year after 10 years. This represents a loss of around 3% of genetic progress in profitability after three years.

Selection on sub-indexes

Four scenarios were investigated to determine the impact of selection on either of the sub-indexes, production, fertility, calving and beef, alone. The production index consisted milk, fat and protein yield weighted by their respective economic weights. Similarly, the fertility index consisted calving interval and survival, the calving index consisted direct calving difficulty, maternal calving difficulty, gestation length and calf mortality, and the beef index consisted cull cow carcase weight, surplus calf carcase weight, and surplus calf carcase conformation and fat score. The impact of selection on each sub-index on genetic response after ten years is summarised in Table 7.

Table 7. *Expected genetic gain in individual animal genetic merit after ten years of selection on alternative sub-indexes based on a genetic gain of 0.89 genetic SD after ten years.*

Trait / Index	Production	Fertility	Calving	Beef
$EBI_{CURRENT}$ (€)	27.50	30.89	11.95	5.57
EBI_{CALV} (€)	27.77	33.22	22.62	4.72
EBI_{BEEF} (€)	29.70	28.66	11.04	13.58
EBI_{CALV_BEEF} (€)	29.97	31.00	21.72	12.72
Production index (€)	43.15	-16.75	1.15	12.04
Fertility index (€)	-15.66	47.63	10.79	-6.47
Calving index (€)	0.28	2.34	10.68	-0.85
Beef index (€)	2.20	-2.23	-0.90	8.01
Milk (kg)	173.67	-218.10	-50.72	113.01
Fat (kg)	8.04	-5.11	-0.46	2.26
Protein (kg)	9.60	-4.43	-0.18	3.30
Calving interval (d)	1.69	-4.27	-1.00	0.69
Survival (%)	-0.34	1.61	0.34	-0.15
Direct calving difficulty (%)	-0.11	-0.56	-1.80	0.34
Maternal calving difficulty (%)	0.00	0.08	0.32	-0.05
Gestation (d)	0.02	-0.18	-1.17	0.05
Calf mortality (%)	-0.02	0.00	-0.24	-0.11
Cow carcase weight (kg)	2.51	-4.52	-2.07	8.86
Calf carcase weight (kg)	2.38	-2.36	-0.81	7.39
Calf carcase conformation	-0.10	0.18	0.09	-0.11
Calf carcase fat score	-0.05	0.10	0.07	-0.21

As expected selection on either of the sub-indexes maximised genetic gain in the respective index. Selection on the production index resulted in the largest reduction in the fertility index,

attributable to an increase in calving interval and a reduction in survival. Such trends are consistent with (inter)national reported antagonistic genetic correlations between milk production and fertility. Selection on the production index is also expected to increase calving performance and beef performance and reduce carcase conformation and carcase fat. Slectionon the fertility sub-index alone is expected to have the greatest effect of all sub-indexes on reducing response to milk production. Selection on fertility alone also manifests itself as a reduction in genetic response in overall beef merit. Selection on calving performance alone reducing carcase weight, improves genetic response in fertility and has minimal effect on milk production response. Selection on the beef index alone, reducing calving performance to the greatest degree and increases production. The genetic response expected for selection on any of the subindexes is expected to be lower than selection on the overall total index (including all sub-indexes).
It is important to remember that the rate of genetic gain in standard deviation units after ten years was constant across all sub-indexes which may not necessarily h
old. For example the rate of genetic gain in the fertility index may be lowest given its lowest expect heritability. Nevertheless, the trends in response will remain the same although the absolute response may differ.

Double counting

Relationships exist among traits and therefore the effect of genetically altering a single characteristic of an animal often influences other correlated traits. For example, increasing milk yield by 1kg will, on average, also increase fat and protein yield. However, in animal breeding, the economic value of a trait is defined as the profit accruing from one incremental change in the trait under investigation while all other traits in the breeding objective remain constant. For example, the economic value for milk yield is the change in profitability from increasing milk yield by 1kg while fat and protein yield remain constant (i.e., the consequence of increasing milk carrier by 1 kg). Fat and protein yield will increase, but their increases will be identified through the superior genetic merit of the sire for fat and protein yield which in turn have their own economic value in the EBI.

Similar phenomena occur with changes in calving difficulty and gestation length. Changes in calving difficulty have repercussions for production and reproduction of the animal as well as mortality in the resulting calf; similar consequences are evident for gestation length. Therefore, care must be taken to avoid double counting of traits in the EBI. Double counting occurs only when a trait of a sire affects traits in his daughters that are included in the breeding objective.

Sires may also affect the same traits in cows he is mated to, but which are not his daughters, and hence there is no issue of double counting. The issue of double counting is described in more detail on a trait by trait basis.

Market failure

Market failure is the phenomenon that occurs when a farmer purchasing an animal does not pay a premium for that animal to reflect its genetic merit. This is relatively rare among trading of purebred dairy animals between dairy farmers (i.e., a farmer will pay a bonus for a replacement heifer of superior genetic merit). Circumstances may differ when germplasm is transferred between dairy and beef herds, not operated by the same individual. Under zero market failure, beef farmers will pay premiums for beef*dairy crossbred females of superior genetic merit (i.e., beef farmers may actively seek female replacements from British-Friesian or dual purpose type dairy cows). Under complete market failure, no financial benefits will be relayed back to the dairy farmer. In reality, the intensity of market failure is somewhere in between. However, the mission statement of ICBF is "To achieve the greatest possible genetic improvement in the national cattle herd for the benefit of Irish Farmers, the Dairy and Beef industries and Members" (i.e., to maximise genetic gain in profitability across all cattle). Thus, ICBF may choose to ignore market failure thereby servicing the entire cattle industry as a whole.

It is important to bear in mind that some annual traits may be economically relevant in dairy enterprises but not in beef enterprises. For example, the genetic merit of a dairy sire for milk yield will be irrelevant to a beef farmer; hence the expressions of these traits in beef herds should not be included in the CDE of a dairy sire for lactation milk yield.

Cumulative discounted expressions

Berry et al. (2005) using input parameters derived from the national population calculated the cumulative discounted expressions (CDEs) of six alternative trait categories: annual cow traits, replacement heifer traits, cull cow traits, birth traits, weaning/yearling traits and slaughter traits. It is proposed that the EBI continues to be expressed on a per lactation basis. The calculated CDE for annual cow traits following an initial mating between two dairy sires in Ireland and the existence of complete market failure is 0.79 (Berry et al., 2005). Complete market failure was assumed since the milk producing ability of a dairy sire, used to produce dams of suckler cows, is likely to be irrelevant to a beef farmer. The CDE is multiplied by two for use with predicted differences in the EBI. In order to maintain all expressions on a per lactation basis the CDE of the remaining five traits categories were scaled back by a factor of 1.58. It is the scaled CDEs that are reported herein.

Milk production and fertility

Economic values for milk yield, fat yield and protein yield have already been described in great detail by Veerkamp et al. (2001) and their revision in 2004 described by Berry et al. (2004). The revised costs and prices were used to update the old values in the 'Moorepark Dairy Systems Model'. These new values were based on up to date replacement costs; future predicted milk price, future predicted fat:protein price ratio, updated levies, the costs of transportation, cooling and processing as well as future cull cow and calf prices. The Food and Agricultural Policy Research Institute Ireland partnership (FAPRI-Ireland) has predicted a male calf value of €102 and a cull cow value of €270; the previous male calf and cull cow value were €190 and €381 (FAPRI, 2003). Quota purchasing cost was reduced from 9.8 cents/litre to 4.80cents/litre. Quota purchase price was assumed to be €1/gallon and the money was assumed borrowed over 5 years at 4% interest. The estimated cost included the interest and capital repayments.
Economic values were derived for three different quota scenarios as follows: The first scenario (S1) represents a situation where there is a quota for milk and fat%. The number of cows per farm is fixed but purchase of quota is possible. The second scenario (S2) represents the situation were there was no quota on milk and fat percentage but the number of cows per farm was fixed. The final scenario (S3) represents the situation where there was quota for milk and fat % and the output per farm was also fixed. Economic values for each trait under each scenario were derived for comparison.

The net effect of all changes in the Moorepark model on the economic values is illustrated in Table 8. In the S1 scenario there was no change in the economic value for milk carrier, one kg increase in milk yield (keeping all other traits in the EBI constant) reduced profit per lactation by €0.08. This cost was associated with the cost of transportation, cooling and processing of milk carrier (i.e. milk less the fat and protein). The economic value for fat yield in the S1 scenario increased; despite the reduction in the price per kg fat with implementation of the Fischler proposals. This was because the cost of purchasing quota reduced by relatively more than the reduction in cost of fat meaning that more income can be earned from increased quantity of fat sale. This results in an increase in margin from fat hence the increase in the economic value. The expected decrease in price per kg protein in the future is the main reason for the reduction in the economic value for protein yield. The economic value for survival decreased. A decrease in survival of 0.1% increased returns per cow by €0.57 while income from livestock sales decreased by €0.36 plus higher quota leasing, labour, land and concentrate costs. However, there was a saving on livestock purchases of €1.83 per cow. The economic value for calving interval is likely to increase in future years. The increased importance of calving interval is due to the expected higher future costs of production and the inclusion of revised lactation curves that were more representative of the national dairy herd. In the old model, the economic value of calving interval was made up of +€ 6.60 for increased milk sales, -€ 0.74 for reduced livestock sales and -€ 7.94 for increased total costs which sum up to -€ 2.07. In the revised model, the respective figures are -€ 0.65, +€ 0.20, and -€ 6.64, for milk sales, increased livestock sales, and increased total costs, respectively; the sum of the three parameters is -€ 7.09. Similar explanation can be given for the changes in economic values across the alternative quota scenarios.

Table 8. *The effect of the revision of the bio-economic model on the economic weights of the traits in the EBI under the three different quota scenarios.*

	Old EBI			Revised EBI		
	S1 (€)	S2 (€)	S3 (€)	S1 (€)	S2 (€)	S3 (€)
Milk	-0.08	-0.05	-0.1	-0.08	-0.06	-0.08
Fat	0.86	2.54	-0.42	1.5	2.35	1.61
Protein	5.7	5.7	5.7	5.22	5.22	5.22
Survival	11.4	13.3	9.98	10.77	11.74	10.91
Calving interval	-2.07	-1.08	-2.81	-7.09	-7.24	-7.12

Sensitivity analysis

Altering the price of replacements affected only the economic value for survival; decreasing the cost of the replacement by €200 reduced the economic value for survival from €10.77/percent to €8.74/percent. Altering the milk price in the bio-economic model affected the economic value for fat yield, protein yield and survival. Reducing the milk price from 21.7cents/kg to 18cents/kg reduced the economic value for fat yield, protein yield, and survival to 1.50/kg, €5.22/kg and €10.77/percent survival, respectively. Altering the fat to protein ratio affected the economic value for fat yield and protein yield. Changing the fat to protein price ratio from 1:2 to 1:4 (closer to world market price ratio) reduced the economic value for fat yield to €1.29/kg and increased the economic value of protein yield to €6.38/kg. The ratio of the economic values for fat yield and protein yield was 1:5; the difference between the two ratios of 1:4 and 1:5 is a function of the higher cost of producing 1kg fat compared to producing 1kg protein. Altering the quota purchasing costs only affected fat yield with a small effect on the economic value for survival. The decrease in quota purchasing costs reduced the negative effect of increasing fat yield. If the cost of quota reduced from €1/gallon to €0.85/gallon then the economic value for fat yield would increase to €1.63/kg. The other extreme is if quotas were freely available and this scenario is highlighted in Table 8 (S2).

Cumulative discounted expression

The EBI should be expressed on a per lactation basis. The CDE for each of the aforementioned production and fertility traits is therefore one. Thus the economic weights in the EBI is equivalent to the economic values reported in Table 8.

Calving difficulty

Calving difficulty may be partitioned into two components: direct calving difficulty and maternal calving difficulty. Direct calving difficulty refers to the characteristic of the calf itself (e.g., body size) while maternal calving difficulty describes the characteristics of the dam giving birth (e.g., pelvic dimensions). Estimates of genetic correlations between direct and maternal calving difficulty in dairy cattle, although variable are generally negative (Steinbock *et al*., 2003; Veerkamp *et al*., 2004; for review see Meijering, 1984). Thus, breeding objectives in dairy cattle must simultaneously consider the importance of both direct and maternal calving difficulty in an overall index of profitability.

Economic value

The economic costs of dystocia include increased stockman labour hours, veterinary fees, an increased probability of calf and cow mortality and reduced subsequent cow performance (both production and reproductive). The procedure to calculate the economic value for calving difficulty is outlined in more detail by Amer *et al*. (2001). For the purpose of inclusion in the EBI, the economic value for calving difficulty was defined based on an underlying liability scale within subclasses of sex of calf (M or F) by age of dam (parity 1, 2, ≥3) with the phenotypic values assumed to follow a normal distribution (Meijering, 1980). The phenotypic value of an animal (on the underlying scale) relative to the thresholds will determine the category of assistance required by the animal. The categories of assistance considered were: 1) no assistance; 2) slight assistance, 3) severe assistance, 4) veterinary assistance (excluding caesarean section), and 5) caesarean section.

Because the EBI is a multiple trait breeding index that includes milk yield, fat yield, protein yield, calving interval and survival (Veerkamp *et al*., 2001) it was necessary to derive two distinct economic values for calving difficulty. All costs associated with changes in calving difficulty were included in one estimate (full economic value) and all costs, excluding those associated with reduced milk production and fertility/survival, were included in the second estimate (reduced economic value) to avoid double-counting. It is also proposed to include calf mortality in the EBI. Therefore the cost of calf mortality associated with calving difficulty was not included in the economic value for calving difficulty; this is different to Amer *et al*. (2001) where a value for the probability of calf mortality was included in the economic value for calving difficulty.

Table 9. *Full economic value of a 1% change in the proportion of cows requiring severe calving assistance or worse in a dairy herd.*

Item	Caesarean	Veterinary assistance	Severe assistance	Slight assistance	Herd average cost
Stockman hours	6	4	4	1	
Stockman cost (€) per hour	13	13	13	13	
Veterinary costs (€)	160	40	0	0	
Probability of a dead cow	0.05	0.025	0.025	0	
Cost of a dead cow (€)	1319	1319	1319	1319	
Reduced reproductive success	0.25	0.1	0.05	0	
Barren cow costs (€)	1026	1026	1026	1026	
Lost milk (litres)	600	150	50	0	
Cost of lost milk (€)	0.17	0.17	0.17	0.17	
Calving cost relative to no assistance	662	253	145	13	
Percentage of calvings with 6% difficult	0.97	2.51	2.52	20.28	20.82
Percentage of calvings with 7% difficult	1.19	2.94	2.86	21.91	24.30
Economic effect (€) per cow of 1% change					-3.25

Table 10. *Reduced economic value of a 1% change in the proportion of cows requiring severe calving assistance or worse in a dairy herd.*

Item	Caesarean	Veterinary assistance	Severe assistance	Slight assistance	Herd average cost
Stockman hours	6	4	4	1	
Stockman cost (€) per hour	13	13	13	13	
Veterinary costs (€)	160	40	0	0	
Calving cost relative to no assistance	238	92	52	13	
Percentage of calvings with 6% difficult	0.97	2.51	2.52	20.28	10.32
Percentage of calvings with 7% difficult	1.19	2.94	2.86	21.91	11.86
Economic effect (€) per cow of 1% change					-1.31

Calculation of total costs for each assistance category in excess of those of the "no assistance" category are summarised for the full and reduced economic values in Tables 9 and 10, respectively. Normally, the replacement rate of a herd does not increase by 1% as the weighted average mortality rate of the herd increases by 1% because older cows that die would need to be replaced anyway in due course. However, this phenomenon was ignored because the incidence of dystocia is most prevalent in primiparous cows (Meijering, 1984) and there is a one to one relationship between lost first calvers and the herd replacement rate (Amer *et al*., 2001).

The cost of a dead dairy cow is therefore equivalent to the cost of a replacement heifer currently included in the bio-economic model for the calculation of the economic values in the EBI (Berry *et al*., 2004). The cost of a barren cow is the cost of a dead cow less the salvage value of a cull cow. The salvage value of a cull cow was assumed to be €293 based on FAPRI predictions (FAPRI, 2003) adjusted for price differentials depending on calendar month of sale; this is the current weighted average cull cow value used in the calculation of the economic values in the EBI (Berry *et al*., 2004).

When calf mortality associated with a 1% change in calving difficulty is included in the calculations, then the full and reduced economic values for calving difficulty are -€3.47 and -€1.53, respectively.

Further explanation regarding the calculation of the economic value for calving difficulty based on the probability of assistance is outlined in Appendix I.

Cumulative discounted expressions

The CDE of a dairy sire when mated to a dairy female were calculated for birth and annual cow traits using parameters extracted from national data (Berry *et al*., 2005). The CDE for birth and annual cow traits (when multiplied by two for use with predicted differences in the EBI) were 2.10 and 1.78, respectively. When rescaled to annual traits the respective CDE were 1.33 and 1.13. The expression of direct calving difficulty is synonymous with birth trait expressions while the expression of maternal calving difficulty is synonymous with annual cow trait expressions.

The direct calving difficulty effect of a sire in the initial mating with a dairy dam will not be reflected in a differential in EBV for milk production and fertility/survival of the sire himself. This occurs since it is the dam (which is unrelated to the sire) that may experience the loss in production/reproductive performance thereby having no effect on the EBV of the sire himself. Thus, the initial expression of direct calving difficulty incurs the full economic cost. The CDE of this trait is one.

The remaining CDE for birth traits (i.e., 2.10 less 1.00) reflects the direct calving difficulty in the female replacement descendants of the sire of interest. This effect is the result of the characteristics of the calf attributable to the genes of the initial sire in his female descendants. The attributes of direct calving difficulty in the sire's female descendants will be reflected in the sires EBV for production/reproduction and thus the remaining CDE will incur the reduced economic value.

The impact on production and fertility/survival from differences in maternal calving difficulty will be reflected in the EBV of the sire through the traits already included in the EBI. Thus, the repercussions of impaired calving difficulty on these traits will be ignored and all expressions of maternal calving difficulty will be included in the EBI at the reduced economic value.

Economic weight

The economic weighting for direct calving difficulty (DEW_{CE}) and maternal calving difficulty (MEW_{CE}) within the EBI equate to

$$DEW_{CD} = (FullEV_{CD} * 0.63) + (RedEV_{CD} * [1.33 – 0.63])$$

$$MEW_{CD} = (RedEV_{CD} * 1.13)$$

Where $FullEV_{CD}$ = full economic value, $RedEV_{CD}$ = reduced economic value, CDE_{birth} = cumulative discounted expression for birth traits, CDE_{annual} = cumulative discounted expression for annual traits. Thus, DEW_{CD} = -€2.96 and MEW_{CD} = -€1.48.

Comment [DB1]: It appears that the arithmetic for this value was incorrect

The CDE for birth and annual traits will differ with the intensity of market failure (Berry *et al.*, 2005). As the intensity of market failure increases the CDE will decrease. In a situation of complete market failure whereby the superior genes of a dairy sire expressed in a crossbred suckler replacement are not relayed back to the dairy farmer then CDE_{birth} and CDE_{annual} are 1.9 and 1.58, respectively (Berry *et al.*, 2005).

Gestation length

Possible non-linear relationships between gestation length and calving difficulty (i.e., both short and long gestation length may predispose animals to higher incidences of dystocia) question the validity of selection for gestation length (Meijering, 1984). However, the genetic standard deviation for gestation length is low and thus genetic change will be small. If not included in the EBI, gestation length may lengthen based on correlations with other traits in the EBI. Relationships between short gestation length and dystocia may also be due in part to abortions. Therefore, records with very short gestation length should not be included in the genetic evaluation for gestation length.

Economic value

The economic value for gestation length manifests itself through a longer subsequent breeding season and thus less barren cows (Amer *et al*., 1996). Additional benefits of shorter gestation length are the possibility for longer lactations and a longer period of growth for calves born earlier. Like calving difficulty, gestation length may be partitioned into direct and maternal components.

Assuming gestation length is independent of calving to conception interval then each one day increase in gestation length is synonymous with a corresponding one day increase in calving interval (i.e., we assume that the genetic regression coefficient of gestation length on calving interval should equal one because of the part-whole relationship between the traits, and the unlikely existence of a strong genetic correlation between gestation length and the calving to conception interval). The economic value for calving interval currently included in the EBI is -€7.09/day. Thus, the economic value for gestation length is -€7.09/day.

Cumulative discounted expression

A sire's genes for gestation length are expressed once through his initial calf when he is mated to any cow (i.e., direct gestation length), but are also expressed annually in a selected portion of his self-replacing daughter descendants (i.e., direct and maternal gestation length). The CDE for birth and annual traits were reported by Berry *et al*. (2005) for Ireland. Again, these CDE should be multiplied by two since genetic merit for gestation length will be reported in predicted differences within the EBI; thus the halving of the genes of the sire when passed onto his progeny is already included in the calculation of the predicted differences.

Economic weight

The CDE for direct gestation length from the initial mating is one. Any repercussions of subsequent expressions of direct gestation length will already be included through the EBV of calving interval for the sire; similar conclusions exist for maternal gestation length. The economic weight for direct gestation length (DEW_{GL}) and maternal gestation length (MEW_{GL}) is therefore:

$$DEW_{GL} = (EV_{GL} * 0.63) + (0 * [CDE_{birth} - 0.63])$$
$$MEW_{GL} = (0 * CDE_{annual})$$

Thus, the economic weight for DEW_{GL} and MEW_{GL} are -€4.49, and €0.00, respectively.

Calf Mortality

Economic value

Mortality affects profitability through the loss of a calf. Thus, the economic value for calf mortality is the opportunity cost of the calf (i.e., the price obtainable for a newborn calf). Similar, to calving difficulty and gestation length, calf mortality is influenced through direct and maternal genetic effects (Steinbock *et al*., 2003). Male calf value and female calf value were assumed to be €102 and €315, respectively in accordance with prices included in the bio-economic model based on FAPRI projections (FAPRI, 2003). In 2003, 57% of stillbirths were males. The weighted average value of a black and white calf was therefore assumed to be €193.59. Hence, the economic value per percentage increase in calf mortality is -€1.94.

Cumulative discounted expression

The CDE for direct calf mortality is synonymous with the CDE for birth traits reported by Berry *et al*. (2005) while the CDE for maternal calf mortality is synonymous with the CDE for annual traits reported by Berry *et al*. (2005).

Economic weight

Calf mortality does not affect other traits included in the EBI and the traits included in the EBI that affect calf mortality (i.e., calving difficulty, gestation length) do not include possible effects on calf mortality in their economic value. Hence, no issue of double counting arises.

Thus, the economic weight for direct calf mortality (DEW_{MORT}) and maternal calf mortality (MEW_{MORT}) is:

$DEW_{MORT} = (EV_{MORT} * 1.33)$

$MEW_{MORT} = (EV_{MORT} * 1.13)$

Therefore, the economic weights for direct calf mortality and maternal calf mortality are -€2.58 and -€2.19. Because EBVs for maternal calf mortality will not be calculated only direct calf mortality will be considered further for inclusion in the EBI.

Cow carcase weight

Economic value

The economic value for cow carcase weight is a function of three separate factors. The revenue from increased carcase size, the cost of increased maintenance of the cow and the cost of the increased energy demands of the cow as a growing nulliparous female.

The revenue attainable from a cull cow carcase is a function of the average carcase price per kg. However, animals slaughtered at a carcase weight of less than 272 kg are heavily penalised; it is assumed that they receive half the average cull cow price. Thus, as carcase weight increases the carcase value increases by the average carcase price per kg for each incremental kg increase in carcase weight. However, the proportion of cows with a carcase weight of greater than 272 kg also increases thereby increasing the average carcase price per kg across the population. Data on cull cow carcase weight for over 25,000 black and white cows throughout the years 2002 to 2004 were used to determine the percentage of carcases slaughtered at a carcase weight of less than 272 kg as well as the phenotypic standard deviation for carcase weight. The phenotypic standard deviation for carcase weight was 50kg and 27% of carcase weights observed were less than 272 kg. Following an average increase in carcase weight by 1kg, 0.7 percentage units of animals crossed over the 272 kg carcase weight threshold thereby commanding higher carcase price and contributing to the economic value for carcase weight. The weighted average price of O3's was €1.61 /kg carcase weight. Thus, the economic benefits of a kg increase in carcase weight is €3.00.

The bio-economic model (Shalloo et al., 2004) includes a variable for cow live-weight as well as grass growth rate patterns; this facilitated the calculation of maintenance cost per incremental kg increase in live-weight. The maintenance cost per lactation for each incremental kg increase in liveweight was €0.167/year. Assuming a 45% kill out percentage this equates to €0.371/kg carcase weight (i.e., €0.167/0.45).

In order for the cow to attain the heavier weight she also requires an additional amount of energy as a growing female. Every additional 1kg increase in liveweight requires an additional 4.5UFL of energy throughout the growing process (Jarrige, 1989). We can estimate the amount of this energy that comes from grazed grass, grass silage and concentrate. We can then convert this to kg of dry matter required and from there we can cost the additional energy required (Table 11). Assuming a kill out percentage of 45%, the growing cost to increase carcase weight by 1kg is €0.88 (i.e., €0.398/0.45).

Table 11. *Diet composition and cost for a growing heifer for each additional kg increase in live-weight*

	UFL	KgDM	Costs /kgDM (€)	Total Cost (€)
65% Grass	2.93	2.87	0.058	0.166
25% Grass Silage	1.13	1.61	0.111	0.179
10% Concentrate	0.45	0.41	0.13	0.053
TOTAL				€0.398/kg LW

Cumulative discounted expression

Each of the three components of cow live-weight are expressed at different frequencies over different time horizons. Carcase weight is synonymous with “cull cow traits”, cow maintenance requirements is synonymous with “annual cow traits” while heifer growth requirements is synonymous with “heifer replacement traits” as reported by Berry et al. (2005).

Economic weight

The economic weight for cow carcase weight (EW_{COWCW}) was calculated as

$EW_{COWCW}=(EV_{Carcase\ weight}*0.24)+(EV_{maintenance}*1.13)+(EV_{growth}*0.35)$

Where each of the numerical coefficients represent the CDE for the respective trait. Thus, the economic value for cull cow carcase weight is €0.04/kg

Calf carcase weight

Economic value

Amer et al. (2001) described carcase attributes using three parameters: carcase weight, carcase conformation score and carcase fat score. Each of the three descriptors was allocated a separate economic value.

The economic value for carcase weight is the price attainable per kg carcase less the cost of increased dry matter intake associated with the increase. A projected future base carcase price of €2.40 was assumed. A projected price differential to O4L was assumed to be -€0.12 (Farmers Journal, 18th December 2004). Thus, the projected carcase price for a typical O4L steer is €2.28/kg carcase weight.

Calculation of the cost per unit effective energy is summarised in Table 12. Effective energy of the feedstuff are calculated as outlined by Emmans (1994)

Table 12. *Cost, metabolisable energy content (ME), digestible crude protein content (DCP), effective energy (EE) content and cost per MJ effective energy for silage and concentrates as well as a finishing diet (80% grass silage, 20% concentrates).*

	Cost (€/t DM)	ME (MJ/kg DM)	DCP (g/kg DM)	EE (MJ/kg DM)	EE cost (cent/MJ)
Silage	111	10.8	140	10.46	1.06
Concentrates	190	13	120	8.02	2.37
Silage / concentrate 0.8/0.2					1.32

Based on the procedures of Amer and Emmans (1998), assuming the costing structure in Table 12 and that the degree of maturity at slaughter in protein is 80%, the cost for each extra kg increase in carcase weight is €1.06. This is similar to the cost predicted (€1.13) assuming a correlation of 0.70 between lifetime dry matter intake and carcase weight assuming a standard deviation of 420 kg and 20 kg for lifetime dry matter intake and carcase weight, respectively, and an average cost of €0.07/kg DM.

Thus, the economic value for carcase weight is €2.28-€1.06=€1.22/kg. This accounts for increased revenue accruing from the sale of an extra kg of carcase weight, grading O4L and the increased maintenance and growth cost of the extra kg carcase weight.

Cumulative discounted expressions

The CDE for slaughter traits reported by Berry et al. (2005), expressed for use with PTAs and scaled back to a per lactation basis by a factor of 1.58 is 0.75.

Economic weight

The economic weight for calf carcase weight (EW_{CCAR}) is:

$$EW_{CCAR}=EV_{CCAR}*0.75$$

Thus, the economic weight for calf carcase weight is €0.92/kg

Calf carcase conformation

Economic value

It is assumed that the carcase price at a fixed carcase weight is comprised of the values derived from the weight of meat cuts from the loin, the hind quarter, plus the weight of the remaining meat cuts. In other words, no economic value is assigned to the value of bone, offals and trimmings etc derived from the carcase. From this, the economic value of an increase in the weight of "other" cuts (EV_OC) can be calculated as

$$EV\_OC = \frac{CP}{rLC \cdot RL + rHC \cdot RH + rOC}$$

where CP is the carcase price per kg (€2.40), rLC is the proportion of all cuts which are loin cuts (0.115), RL is the ratio of the price of loin cuts relative to the price of "other" cuts (5.3), rHC is the proportion of the carcase which is hind-quarter cuts (0.245), RH is the ratio of the price of hind-quarter cuts relative to the price of "other" cuts (2.2) and rOC is the proportion of the carcase which is non loin cuts (0.640). The economic value of loin cuts is then taken as

$$EV\_LC = EV\_NLC \cdot RL$$

and the economic value of hind-quarter cuts is taken as

$$EV\_HC = EV\_NLC \cdot RH$$

Using the derived values for the parameters as shown above, economic values for weights of other cuts, loin cuts, and hind-quarter cuts, at a constant carcase weight are €1.34, €7.10 and €2.95 respectively.

Currently, there is no data available of sufficient structure to estimate genetic relationships between recorded traits and the meat cuts profit traits. This is because the number of processors who currently capture cut weights is small. It is anticipated that in the future, mechanical grading systems will lead to accurate predictions of cut weights, and these will be able to be included as selection criteria as they are captured and stored on the national database.

At present, the data that is being captured is limited to carcase weight, carcase fat score and carcase conformation score. Carcase conformation score was recoded to a 15 point scale prior to genetic analysis. Thus, in the interim, predictions of the goal traits of loin, hind-quarter and other cuts at a constant carcase weight will have to rely on

1. the ability of recorded traits to predict conformation scores
2. the expected change in cut weights with a unit change in carcase conformation score.

Therefore, the economic weights will be applied to carcase conformation score, based on the relationships between carcase conformation and cut weights. Data on carcases of suckler herd owners where both carcase conformation and cut weights have been measured were used to estimate the relationships between carcase conformation (recoded to a 15 point scale) and cut weights. The resulting (phenotypic) coefficients and calculations to get the economic values for carcase conformation described in Table 13.

Table 13. *Regression coefficients for the three cut traits on carcase conformation and the respective economic values*

Cut trait	Carcase Conf. score (15pt scale)	Cut economic weight (€/kg)	Contribution to EW
Loin cuts	0.285	7.10	2.02
HQ cuts	0.829	2.95	2.45
Other cuts	0.576	1.34	0.77
Interim economic weight			**5.24**

Cumulative discounted expressions

The CDE for slaughter traits reported by Berry et al. (2005), expressed for use with PTAs and scaled back by a factor of 1.58 is (i.e., to scale all expressions to a per lactation basis) 0.75.

Economic weight

The economic weight on calf carcase conformation score (EW_{CCONF}) is:

$EW_{CCONF}=EV_{CCONF}*0.75$

Thus the economic weight for calf carcase conformation score is €3.93

Calf carcase fat score

Economic value

The economic value for carcase fat score was calculated from the relationship between carcase fat score and cut weights. The phenotypic coefficient between fat score and cut traits and calculations to get the economic values for carcase conformation are described below.
Fatter carcasses will have lower weights of all types of cuts at the same carcase weight. Thus with a breeding objective based on cuts most of the economic influence of fatness will be implicit, rather than explicit in the breeding objective.

However, because cut data is unavailable, in the interim, the economic weight applied to carcase fat score, will be based on the relationships between carcase fat score and cut weights at a constant carcase weight. The phenotypic coefficients and calculations to get the economic values for carcase fat score are described in Table 14.

Table 14. *Regression coefficients for the three cut traits on carcase fat score and the respective economic values*

Cut trait	Carcase Fat score (15pt scale)	Cut economic weight (€/kg)	Contribution to EW
Loin cuts	-0.315	7.10	-2.24
HQ cuts	-0.950	2.95	-2.80
Other cuts	-2.35	1.34	-3.15
Interim economic weight			**-8.19**

No account of the contribution of fatness to eating quality is taken, under the assumption that beef of exclusively dairy origin will not be exported in a form, and to markets, where fat cover is desirable.

Cumulative discounted expressions

The CDE for slaughter traits reported by Berry et al. (2005), expressed for use with PTAs and scaled back by a factor of 1.58 is 0.75.

Economic weight

The economic weight on surplus calf fat score (EW_{CFAT}) is:

$EW_{CFAT}=EV_{CFAT}*0.75$

Thus the economic weight for surplus calf fat score is -€6.14

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Appendix 1

The probability of assistance types were calculated within sex of calf by age of dam (parity 1, 2, ≥3) combinations. Percentages of specific assistance types were computed assuming threshold differences of 1.07, 0.3, and 0.6 between slight assistance, severe assistance, veterinary assistance and caesarean section, respectively.

Let $p(u)_i$ denote i=1 to t probabilities of a normally distributed calving liability falling within the pair of thresholds T_i and T_{i+1} given a population mean u; let a_i denote calving costs associated with calving liabilities between T_i and T_{i+1}. The average cost of calving (SC) in a subpopulation of sex by dam age-class with mean liability of u was calculated as:

$$SC(u) = \sum_{i=1}^{t} a_i \, p(u)_i$$

By setting a_i to zero, the proportion of unassisted calvings is ignored, and so the equation above results in the average expected costs in excess of those from unassisted calvings.

If cows of different age groups carrying different sexed calves are treated as sub-populations then the average calving costs for the whole population (EC) may be calculated as:

$$EC(u) = \sum_{j=1}^{6} SC(u_j) q_j$$

where u_j is the mean of the subpopulation j (j=1 to 6) and q_j is the proportion of the total number of animals that reside in each subclass j. For dairy cows, the proportions q were assumed to be 0.33, 0.25 and 0.42 for heifers, first calvers and older dams, respectively. A calf sex ratio of 50:50 was assumed.

The economic value of a one unit change in calving difficulty on the underlying normal scale for the whole population is calculated as the partial derivative of the equation for expected calving costs.

The values of u for which the economic values were derived were obtained by back-solving to obtain proportions of an average herd of cows requiring assistance which correspond to proportions observed in practice.