The industry structures required to maximise genetic gains in the Irish beef industry

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# Executive Summary

* A benefits model for Gene Ireland and the Gene Ireland Bull Breeder (GIBB) herd program was created using the current pedigree and commercial Limousin herds as a case study.
* Scenarios looked at the base beef data and genomics programme (BDGP) and modifying the following factors:
  + the flow of genetic contributions to increase the usage of types of selection candidates such as Gene Ireland AI bulls and stock bulls from GIBB herds
  + incorporating genomics via earlier use of Gene Ireland AI bulls, selection of PT candidates from all herds using genomics, and increasing the merit of the GIBB stock bulls used through higher accuracy of selection
  + Increasing the merit of the foreign AI bulls used
  + Increasing the proportion of replacements sourced from the dairy herd
  + Compounding favourable changes
* The total and annualised benefits from genetics were compared for each scenario over 10, 15 and 20 years
* The BDGP scheme alone led to substantial industry benefits after 20 years, without any changes to sire usage. This is through smaller, more efficient, more fertile and milkier suckler cows.
* Breeding strategies focusing solely on GIBB herds had limited impact. There are just not enough of these herds, they are not selling enough stock bulls, and flows of genes from these herds are not a large factor in the overall flows of genes.
* The best returns came from wider usage of the Gene Ireland AI bulls within the pedigree and GIBB herds, with scenarios that modelled 30% usage of Gene Ireland AI in all pedigree herds resulting in total benefits 77% higher than the BDGP scheme alone after 20 years.
* The challenge in increasing the usage of Gene Ireland AI sires will be changing farmer behaviour and reducing the reliance on foreign AI sires (70% of calvings in GIBB herds are from foreign sires).
* Greater sourcing of suckler herd replacements from the dairy herd will dilute down the long term impacts of genetic gains in beef breeds.
* While there would be gains from sourcing better foreign bulls, by using the genomic test from Ireland to screen candidates for importation, these benefits are not compounding.
* Much greater gains will be realised when bulls are sourced to enter the Gene Ireland progeny test process based on genomic testing across as wide a pool of pedigree bulls as is practical and cost effective.

# Introduction

ICBF launched the Gene Ireland Maternal Beef Breeding program in Autumn 2012 in conjunction with industry partners to encourage high quality data recording on maternal traits and progeny testing of suitable young beef bulls for maternal traits. Following the introduction of the suckler beef genomics program and the beef data and genomics program (BDGP), ICBF wished to estimate the benefits of the Gene Ireland maternal beef program, as well as the Gene Ireland qualified maternal beef breeders (GIBB) initiative and how these benefits may change with the introduction of genomics. A model estimating the benefits of genetic gain over time was created and has been parameterised using data from the Limousin breed. The model has also been used to project benefits at a whole of industry level.

This document describes the model used to estimate the benefits to Irish beef farmers from ongoing genetic improvements driven by flows of genes from superior sires from overseas, from pedigree herds within Ireland, and from the Gene Ireland progeny test scheme, both via natural mating and artificial insemination. The model has been parameterised using detailed industry statistics including current gene flows characterised by numbers of matings by different types of sire types, and the expected amount of variation in estimated breeding values for these sire types. A number of different scenarios are then compared, to identify changes in current structure and practices that will increase the benefits from ongoing genetic improvement initiatives and new technologies such as genomics.

# Model Overview

A recursive model with multiple flows of predicted genetic merit across herd and animal mating types is used to track the impacts of selection decisions on the commercial performance of replacement heifers in beef suckler herds. The model is initially parameterised based on numbers of observed mating types for animals descending from Limousin sires, the level of variation in predicted genetic merit for “Replacement Index” in various types of male selection candidates, and modest levels of selection intensity. It is then possible to look at the impact of either

* Changing the flow of genetic contributions so that specific types of selection candidates (e.g. Gene Ireland proven elite sires) have a bigger genetic impact on both the pedigree and commercial levels of the population
* Changing the accuracy of selection and/or selection intensity at various key selection points (e.g. in selecting the genetic merit of GIBB sires used in other GIBB herds by either AI, or by natural mating)
  + This includes modifying the number of selection candidates available for Progeny testing as part of the Gene Ireland program and those selected as Gene Ireland sires.
* Reducing the age at which elite bulls can be identified, and as such reducing the lag between realised genetic progress and the trend in genetic merit in future generations and the commercial tier
* Determining the value of the Gene Ireland maternal beef program, and the genetic impact required from these bulls to make the cost of the program per year worthwhile.
* Changing the superiority of foreign AI bulls used in the pedigree levels of the population
* Determining the effect of sourcing more replacements from dairy crosses.
* Compounding benefits of favourable changes in accuracies, selection intensities and usages in pedigree and commercial herds.

The model was also used to determine the benefits of the Beef Genomics Data Program (BGDP) which requires farmers to keep better replacements.

# Inputs

Sire usage statistics were estimated using data on all Limousin pedigree animals currently alive, combined with lists of current AI and stock bulls and the list of herds that meet GIBB standards. The sire usage in commercial herds was estimated using calving data from the herd changes analysis[[1]](#footnote-1) (calvings between 2010 and 2014) with sire information from active AI and stock bull lists, depending on whether bulls without AI codes could be matched to any of the pedigree or GIBB herds. In the commercial calving data where sire data were missing, calvings were categorised as “Non pedigree stock bulls”. The usage of Gene Ireland bulls is currently very low as the program was initiated in 2012 and the bulls enrolled in the program are still relatively young.

Table 1 shows the breakdown of sire usage in GIBB pedigree breeding herds, other non-GIBB pedigree herds and commercial herds. The sire types used were as follows;

* Gene Ireland AI bulls
* GIBB born stock bulls used as sires in the same herd as their birth herd (home bred)
* GIBB born stock bulls, used as sires in a different herd to their birth herd
* non-GIBB pedigree herd stock bulls used as sires in the same herd as their birth herd (home bred)
* non-GIBB pedigree herd born stock bulls
* non-GIBB pedigree herd born AI bulls, identified as AI bulls with pedigree herd birth data – this includes AI bulls born in GIBB herds prior to the GI maternal beef program
* Stock bulls not born in pedigree herds identified from the commercial pedigree file
* Foreign stock bulls, identified as having either a foreign country code in ITT and having no AI code
* Foreign AI bulls, includes bulls with AI code and no match to Irish pedigree file data (no ITT).

Table 1: Sire usage by type in GIBB, other non-GIBB pedigree herds and commercial herds.2

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Bull type | GIBB usage | Other pedigree herd usage | Commercial herd usage | Dairy herd usage |
| Gene Ireland AI | 0.1% | 0.1% | 0% | 0% |
| GIBB homebred stock bulls | 2.1% | N/A | N/A | N/A |
| GIBB born stock bulls | 4% | 1.9% | 5% | 10% |
| Non GIBB homebred stock bulls | N/A | 3.5% | N/A | N/A |
| Non GIBB stock bulls | 11.1% | 28.2% | 46% | 60% |
| Non GIBB AI | 7.7% | 13.8% | 9% | 10% |
| Non pedigree stock bulls | 0% | 0% | 25% | 20% |
| Foreign stock bulls | 3.7% | 1.7% |  | 0% |
| Foreign AI | 71.1% | 50.7% | 15% | 0% |

2N/A indicates where it would be impossible, by definition, to have a value in this cell

In order to account for the lag between selection decisions and the flow on of benefits from using bulls of each type, the proportion of calvings in each herd type at each sire age were calculated. As the first Gene Ireland bulls were only around 2 years old at the time of undertaking this analysis, it was assumed that their main usage would occur when they are older and identified as being superior for maternal traits based on daughter performance in Gene Ireland Progeny Test (GIPT) herds.

Table 2: The proportion of calves born by sire age for each sire type in both pedigree (including GIBB) and commercial herds.

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Sire Age | Gene Ireland3 | GIBB HB NM | GIBB NM | Non GI HB NM | Non GI NM | Non GI AI | Non-ped NM | Foreign AI |
| Pedigree herds | |  |  |  |  |  |  |  |
| 2 | 0 | 0.43 | 0.10 | 0.01 | 0.10 | 0.01 | 0 | 0.01 |
| 3 | 0 | 0.44 | 0.36 | 0.26 | 0.24 | 0.09 | 0 | 0.04 |
| 4 | 0 | 0.11 | 0.21 | 0.32 | 0.21 | 0.12 | 0 | 0.07 |
| 5 | 0.3 | 0.02 | 0.12 | 0.17 | 0.15 | 0.11 | 0 | 0.07 |
| 6 | 0.4 | 0 | 0.10 | 0.12 | 0.11 | 0.14 | 0 | 0.08 |
| 7 | 0.3 | 0 | 0.07 | 0.07 | 0.07 | 0.15 | 0 | 0.09 |
| 8 | 0 | 0 | 0.03 | 0.03 | 0.05 | 0.11 | 0 | 0.10 |
| 9 | 0 | 0 | 0.01 | 0.01 | 0.03 | 0.09 | 0 | 0.10 |
| 10 | 0 | 0 | 0 | 0.00 | 0.02 | 0.05 | 0 | 0.08 |
| >10 | 0 | 0 | 0 | 0.01 | 0.02 | 0.13 | 0 | 0.36 |
| Commercial herds and Dairy herds | | | |  |  |  |  |  |
| 2 | 0 | 0 | 0.08 | 0 | 0.12 | 0.01 | 0.04 | 0 |
| 3 | 0 | 0 | 0.28 | 0 | 0.27 | 0.13 | 0.12 | 0.01 |
| 4 | 0 | 0 | 0.23 | 0 | 0.21 | 0.22 | 0.16 | 0.03 |
| 5 | 0 | 0 | 0.17 | 0 | 0.16 | 0.39 | 0.17 | 0.09 |
| 6 | 0.35 | 0 | 0.11 | 0 | 0.11 | 0.16 | 0.15 | 0.17 |
| 7 | 0.25 | 0 | 0.07 | 0 | 0.07 | 0.02 | 0.12 | 0.18 |
| 8 | 0.2 | 0 | 0.04 | 0 | 0.04 | 0.03 | 0.09 | 0.1 |
| 9 | 0.15 | 0 | 0.02 | 0 | 0.02 | 0.02 | 0.07 | 0.05 |
| 10 | 0.05 | 0 | 0.01 | 0 | 0 | 0 | 0.04 | 0.18 |
| >10 | 0 | 0 | 0 | 0 | 0 | 0 | 0.05 | 0.18 |

3 Gene Ireland proportions are estimates

The other key assumptions that feed into the model of estimated benefits are shown in Table 3 below. The standard deviations of maternal index values were based on available data and from these standard deviations, assumed superiorities in replacement index units were calculated based on selection intensities that correspond to the proportions selected. A ratio of current vs the expected reliability of the Gene Ireland bulls post progeny testing was used to increase the replacement index standard deviation for the Gene Ireland bulls.

Table 3: The parameter values, descriptions and units for the key assumptions driving the recursive model of estimated benefits.

|  |  |  |
| --- | --- | --- |
| Parameter | Description | Units |
| 5 | Selection differential for cows | Replacement index |
| 6 | Selection differential for cows in GIBB herds | Replacement index |
| 2 | Annual gain in merit of foreign bulls used (year on year) | Replacement index |
| 0 | Superiority of foreign AI bulls over all GIBB bulls at base year | Replacement index |
| -5 | Superiority of foreign NM bulls over foreign AI bulls | Replacement index |
| 5 | Superiority of non-GIBB pedigree stock bulls over non-pedigree stock bulls | Replacement index |
| 400,000 | Number of expressions of sire index superiority per year (20% replacements kept x 5 lactations) | Replacement calvings |
| 25% | Proportion of expressions of sire index superiority via beef cross dairy | Percentage |
| 20 | Standard deviation of young bull index values | Replacement index |
| 40 | Standard deviation of young bull index values after progeny born | Replacement index |
| 1.32 | Ratio for increasing the standard deviation of young bull maternal index values to progeny tested bull values | - |
| 52.9 | Standard deviation of Gene Ireland candidates | Replacement index |
| 16 | Superiority of stock bulls from GIBB herds | Replacement index |
| 4 | Superiority of stock bulls from non-GIBB pedigree herds | Replacement index |
| 15 | Replacement index superiority of a dairy cross relative to a suckler replacement | Replacement index |
| 0.65 | Adoption of the BGDP within commercial beef suckler herds | Proportion |
| 30 | Superiority of replacements kept under the BGDP | Replacement index |

# Estimation of benefits

The benefits are estimated recursively from the genetic merit in replacement index units of the calves from the GIBB herds, non-GIBB pedigree herds and commercial herds. Benefits per cow calving are then multiplied by the industry wide numbers of cow calvings that are impacted. The model accounts for the delays and lags for genetic selection decisions at a high level in the breeding structure to cascade down to commercial cows over time. Cumulative discounted benefits were calculated considering benefits from 10, 15 and 20 years of selection. Because of the permanent and cumulative nature of genetic improvement, these benefits were augmented in each case by assuming that the genetic merit achieved at the end of the investment period (i.e. after 10, 15 or 20 years) would be sustained for a further 5 years. The cumulative benefits were then converted into an annualised basis, to allow more simple comparisons with scheme running costs, which typically remain fairly static from one year to the next. Cumulative benefits were converted to annualised equivalents by calculating the annual flow of discounted benefits that would provide the equivalent return as the breeding program over a 10, 15 or 20 year period.

For the GIBB and non-GIBB pedigree herd types, the merit of each sire type is estimated using the selection differential for that sire type over all calves of the same age, combined with the proportion of calves born at each sire age for the given sire type. The estimated merit of sires from these two herd types then feeds into the estimated merit of sires used in the commercial herds, with a lag based on sire age. The estimated merit of sires of each type in the commercial herds is then multiplied by their usage in commercial herds and the number of impacts per year to give the benefit in replacement index units of the sire type. These benefits are then summed across sire type to give the total benefits from genetics for each year.

# Immediate base impact of the BGDP

To model the effect of the BGDP, a lift has been applied to a set proportion of female replacements produced in suckler beef herds (where the proportion is the adoption rate of the BGDP program), and this lift comes from the BGDP requirement that farmers keep better replacement heifers.

# Lift from genomics

The lift from genomics can be incorporated into the benefits model in three different ways. Firstly, by shifting the main usage of the Gene Ireland AI bulls earlier with the same selection differential, i.e. Gene Ireland bulls having 40% of their calvings at 3 years old instead of 6 years old. In addition to earlier usage, genomic selection can be used to source Gene Ireland AI bulls from a larger pool of candidates with a higher accuracy. The third method of incorporating a lift from genomics involves increasing the standard deviations of GIBB and non-GIBB pedigree stock bulls, assuming that higher accuracy in merit could be attained with the use of genomics.

# Two-stage selection

Selection of the Gene Ireland AI bulls involves a two stage selection process, where stage one is the selection of Gene Ireland progeny test candidates from young bulls in the GIBB herds, and stage two is the selection of the Gene Ireland AI catalogue bulls from the progeny test results. The first stage of selection is at a lower accuracy, in this case selecting young bulls on predominantly parent information, then stage two has a higher accuracy as much more information would be available after progeny testing. The resultant selection intensity is lower than the intensity of selecting the top candidates from the entire pool, as it is possible that some of the top candidates may be missed in the first stage, due to the lower accuracy of selection in that first stage.

Table 4: The accuracy, proportion selected and resulting selection intensity for Gene Ireland progeny test candidates

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Scenarios** | Accuracy stage 1 | Proportion stage 1 | Accuracy stage 2 | Proportion  stage 2 | Selection intensity |
| PT bulls must be 4 or 5 stars from GIBB herds | 0.4 | 15/38 | 0.8 | 3/38 | 1.76 |
| PT bulls must be 4 or 5 stars from any pedigree herd – no accuracy penalty with non-GIBB herds | 0.4 | 15/380 | 0.8 | 3/380 | 2.32 |
| PT bulls must be 4 or 5 stars from any pedigree herd – with an accuracy penalty with non-GIBB herds | 0.35 | 15/380 | 0.8 | 3/380 | 2.23 |
| PT bulls must be 4 or 5 stars from any pedigree herd – with a higher accuracy penalty with non-GIBB herds | 0.15 | 15/380 | 0.8 | 3/380 | 1.78 |
| PT bulls must be 3, 4 or 5 star from all pedigree herds, but only 15 Limousin bulls progeny tested | 0.35 | 24/380 | 0.8 | 3/(15/24\*380)4 | 2.14 |
| Double the number of Limousin bulls progeny tested | 0.4 | 30/38 | 0.8 | 3/38 | 1.86 |
| All pedigree herds contributing bulls for PT using moderate accuracy GS | 0.65 | 15/380 | 0.8 | 3/380 | 2.675 |
| All pedigree herds contributing bulls for PT using high accuracy GS | 0.75 | 15/380 | 0.8 | 3/380 | 2.74 |

4Stage 2 proportion based on a larger number of stage 1 candidates, but still selecting the same percentage of candidates.

# Scenarios and results

A large number of scenarios have been evaluated, using the following variations on the status quo (scenario 0):

* Scenario 1 – Status quo with 65% adoption of the BDGP, where replacements are €30 superior in BDGP herds. All following scenarios assume 65% adoption of the BDGP as a base level of impact and incorporate these benefits in the total calculated.
* Scenario 2 – Higher contribution from Gene Ireland AI (30%)– usage increased to 30% of mating in GIBB and non-GIBB pedigree herds, as a consequence, the contribution from foreign AI sires was dropped by an equivalent amount.
* Scenario 3 – Higher contribution from Gene Ireland AI to GIBB only – usage increased to 30% of mating in GIBB herds only, as a consequence, the contribution from foreign AI sires was dropped by an equivalent amount.
* Scenario 4 – Higher contribution from Gene Ireland AI, with double the number of candidates for Gene Ireland.
* Scenario 5 – Higher contribution from Gene Ireland AI (50%) – usage increased to 50% of mating in GIBB and non-GIBB pedigree herds, as a consequence, the contribution from foreign AI sires was dropped by an equivalent amount.
* Scenario 6 –Higher contribution from Gene Ireland AI bulls, with earlier usage due to genomics (30% of usage at 2 years old compared with 5 years old (Table 2)).
* Scenario 7 – Higher contribution from Gene Ireland AI including 20% more commercial AI matings – as a consequence the contribution from non-pedigree stock bulls was dropped by an equivalent amount.
* Scenario 7a – Higher contribution from Gene Ireland AI including 30% more commercial AI matings – as a consequence the contribution from non-pedigree stock bulls was dropped by an equivalent amount.
* Scenario 8 – Higher contribution from Gene Ireland AI but more dairy cross suckler replacements – 50% of the replacements in the suckler herd are sourced from dairy cross replacements instead of commercial beef crosses.
* Scenario 9 – Improved Foreign AI – Foreign AI sires set to be €20 superior to GIBB sires at year 0 instead of equal.
* Scenario 10 – Higher (30%) usage of GIBB stock bulls in all pedigree herds - as a consequence the contribution from foreign AI sires was dropped by an equivalent amount.
* Scenario 11 – Higher (30%) usage of GIBB stock bulls in all pedigree herds as well as 30% usage of Gene Ireland AI in pedigree herds, as a consequence the contribution from non-pedigree stock bulls was dropped by an equivalent amount.
* Scenario 12 – Higher (30%) usage of GIBB stock bulls in all pedigree herds, with genomics – the superiority of the selected GIBB sourced stock bulls is increased due to more accurate genomic selection.
* Scenario 13 – Removal of the restriction that progeny tested Gene Ireland AI candidates only come from GIBB herds, with a decrease in the first stage accuracy of selection from 0.4 to 0.3 due to less recording in non-GIBB pedigree herds.
* Scenario 13a – Removal of the restriction that progeny tested Gene Ireland AI candidates only come from GIBB herds, with a decrease in the first stage accuracy of selection from 0.4 to 0.15.
* Scenario 14 – Sourcing Gene Ireland AI candidates from 3, 4 and 5 star bulls from any pedigree herd (building on scenario 13) but still only progeny testing 15 bulls. The current strategy is to only take 4 and 5 star bulls from GIBB herds.
* Scenario 15 – Selection of Gene Ireland AI candidates by genomic selection from all pedigree herds, with an increased accuracy of stage one selection to 0.65 due to genomics.
* Scenario 16 – Selection of Gene Ireland AI candidates by genomic selection from all pedigree herds, with an increased accuracy of stage one selection to 0.75 due to higher accuracy genomics.
* Scenario 17 – Combining favourable factors with genomics: Gene Ireland candidates selected by genomic selection with an accuracy of 0.75 and earlier usage, 20% usage of Gene Ireland AI in commercial herds, foreign AI was €20 superior to GIBB sires at year 0, and young bulls had a standard deviation of 32.5 units.
* Scenario 18 – Combining favourable factors without genomics: Removal of the restriction that progeny tested Gene Ireland AI candidates only come from GIBB herds, with a decrease in the first stage accuracy of selection from 0.4 to 0.35, 20% usage of Gene Ireland AI in commercial herds and foreign AI was €20 superior to GIBB sires at year 0.
* Scenario 19 – Ideal scenario with full usage of Irish AI and stock bulls in pedigree and commercial herds, Gene Ireland AI candidates selected by genomic selection with an accuracy of 0.75 and earlier usage. Young bulls had a standard deviation of 32.5 units.

The scenarios described above fall into four main categories; increasing the usage of Gene Ireland AI bulls, increasing the usage of stock bulls from GIBB herds, sourcing the progeny test candidates for Gene Ireland from a larger pool, and advantages from utilising genomics. In addition to these categories, scenarios 17, 18 and 19 look at combining favourable factors from scenarios 1 to 16.

Results from the status quo and the scenarios described above are shown as total and annualised equivalents of the cumulative benefits over 10, 15 and 20 years in Table 5

Table 5: The total and annual benefits in €M for 10, 15 and 20 years of benefits from genetics for all 19 scenarios.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Scenario** | **Total benefits (€M)** | | | **Annualised benefits (€M)** | | |
|  | 10 years | 15 years | 20 years | 10 years | 15 years | 20 years |
| 0) Status quo | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1) Status quo with 65% BGDP adoption | 32.4 | 46.9 | 58.2 | 4.6 | 5.1 | 5.5 |
| 2) GI AI increased to 30% in all pedigree herds | 40.0 | 72.2 | 103.0 | 5.7 | 7.9 | 9.7 |
| 3) GI AI increased to 30% in GIBB herds only | 32.9 | 48.4 | 60.9 | 4.7 | 5.3 | 5.7 |
| 4) GI AI increased to 30% with double the number of GI candidates | 41.9 | 76.1 | 108.6 | 6.0 | 8.4 | 10.3 |
| 5) GI AI increased to 50% in all pedigree herds | 40.1 | 73.5 | 105.8 | 5.7 | 8.1 | 10.0 |
| 6) GI AI increased to 30% with earlier usage from genomics | 45.0 | 89.2 | 133.8 | 6.4 | 9.8 | 12.6 |
| 7) GI AI increased to 30% in pedigree herds with 20% usage in commercial herds | 65.9 | 108.1 | 145.4 | 9.4 | 11.9 | 13.7 |
| 8) GI AI increased to 30% in all pedigree herds with 50% of replacements from dairy | 28.7 | 55.9 | 82.5 | 4.1 | 6.1 | 7.8 |
| 9) Foreign AI €20 superior than GIBB bulls at year 0 | 41.9 | 60.3 | 74.2 | 6.0 | 6.6 | 7.0 |
| 10) Increased GIBB stock bull use (30%) in all pedigree herds | 34.5 | 51.4 | 65.4 | 4.9 | 5.6 | 6.2 |
| 11) Increased GI AI (30%) in GIBB herds and GIBB stock bull use increased to 30% in all pedigree herds | 34.9 | 53.1 | 68.3 | 4.9 | 5.6 | 6.2 |
| 12) Increased GIBB stock bull use (30%) in all pedigree herds with higher accuracy from genomics | 38.8 | 59.0 | 75.9 | 5.5 | 6.5 | 7.2 |
| 13) GI PT cands sourced from all pedigree herds, with a penalty on accuracy (acc=0.35 instead of 0.4) | 41.6 | 78.4 | 114.2 | 5.9 | 8.6 | 10.8 |
| 14) GI PT cands sourced from 3/4/5 star bulls from all pedigree herds with a penalty on accuracy | 41.3 | 77.2 | 112.1 | 5.9 | 8.5 | 10.6 |
| 15) GI PT cands sourced from all pedigree herds using genomics with a moderate accuracy (acc=0.65) | 43.1 | 84.2 | 124.8 | 6.1 | 9.2 | 11.8 |
| 16) GI PT cands sourced from all pedigree herds using genomics with a higher accuracy (acc=0.75) | 43.3 | 85.1 | 126.4 | 6.2 | 9.3 | 11.9 |
| 17) Favourable combination of scenarios 2, 16, 6, 9, 7 and 12 (Genomics) | 93.7 | 158.8 | 216.1 | 13.3 | 17.4 | 20.4 |
| 18) Favourable combination of scenarios 2, 7, 9 (no genomics) | 79.1 | 130.4 | 175.7 | 11.3 | 14.3 | 16.6 |
| 19) “Best possible” usage of GI AI and GIBB stock bulls with genomics | 117.9 | 215.2 | 306.6 | 16.8 | 23.6 | 28.9 |

The effect of the BDGP was substantial after 10 years (8 years of benefits after a 2 year lag) with an increase of 32.4M in discounted total benefits from genetics after 10 years, increasing to 58.2M in total benefits after 20 years. The annualised benefits of the BDGP were 4.6M after 10 years, and 5.5M after 20 years.

Scenarios 2 to 8 looked at increasing the usage of Gene Ireland AI bulls, with an increase to 30% usage in all pedigree herds (scenarios 2, 4 to 8) as well as in only the GIBB herds (scenario 3), with the contribution from foreign AI bulls in these herds decreasing by the same amount. Increasing usage in both GIBB and non-GIBB herds led to an additional 7.6M in total benefits after 10 years over the BDGP scheme alone, compared to an additional 0.5M after 10 years when usage was only increased in GIBB herds (Figure 1). Earlier usage (scenario 6) of Gene Ireland AI bulls through genomics added another 5M in total benefits after 10 years, however the largest increase in benefits after 10 years was from Gene Ireland progeny tested bulls having a greater direct impact in commercial herds as well as an increased impact in the pedigree herds. These impacts when combined led to 65.9M in total benefits after 10 years, double the total benefits of the BDGP alone (Figure 3). A further increase in the impact of Gene Ireland AI bulls from 20% to 30% directly into commercial herds increased these benefits to 77.3M after 10 years (7a). Conversely, when 50% of the replacements were sourced from the dairy herd with higher Gene Ireland usage in pedigree herds (scenario 8) the total benefits after 10 years decreased to 28.7M (Figure 3).



Figure 1: The total benefits from genetics per year in €M for scenario 1: the BDGP scheme only, scenario 2: 30% Gene Ireland AI usage in both GIBB and other pedigree herds and scenario 3: 30% Gene Ireland AI usage in GIBB herds only.



Figure 2: The total benefits from genetics per year in €M for scenario 4: 30% usage of Gene Ireland AI bulls in GIBB and other pedigree herds, with double the number of GI candidates, scenario 5: 50% usage of Gene Ireland AI bulls in GIBB and other pedigree herds and scenario 6: 30% usage of Gene Ireland AI bulls in GIBB and other pedigree herds with earlier use through genomics, compared against scenario 1 and 2 from Figure 1.



Figure 3: The total benefits from genetics per year in €M for scenario 7: 30% usage of Gene Ireland AI bulls in GIBB and other pedigree herds with 20% (30% in 7a) in commercial herds as well and scenario 8: 50% of replacements sourced from the dairy herd with (8) and without (8a) 30% usage of Gene Ireland AI.

Scenario 9 (Figure 4) looked at the impact of using foreign bulls with a higher replacement index values, with these bulls set to being €20 superior to all GIBB bulls at year 0 (average superiority of 4 and 5 star replacement index French bulls), with the status quo bull usage and 65% adoption of the BDGP. The initial boost from use of better foreign bulls led to higher total benefits at 10 years when compared to increasing the usage of Gene Ireland AI bulls, however beyond 10 years the benefits plateaued, and the total benefits at 20 years were 74.2M compared with 103M from increasing Gene Ireland AI usage.



Figure 4: The total benefits from genetics per year in €M for scenario 9: setting foreign AI to be €20 superior to GIBB bulls, compared against scenarios 1 and 2.

Scenarios 10 to 12 (Figure 5) looked at the impact of increasing the usage of stock bulls from GIBB herds, on its own (scenario 10), in both pedigree and commercial herds in combination with increasing usage of Gene Ireland AI usage in GIBB herds (scenario 11), and with better selection due to higher accuracy evaluations from genomics (scenario 12). Increasing the usage of GIBB stock bulls led to a modest increase in total benefits, with ~€2M more after 10 years, and €7-10M more than the BDGP alone after 20 years. Using genomics to increase the standard deviation of the young stock bulls led to an additional €4M in total benefits after 10 years increasing to €10M after 20 years, when compared with only increasing the usage of the GIBB stock bulls. Combining more Gene Ireland AI usage with 30% usage of GIBB herd stock bulls led to €39.9M in total benefits after 10 years, which was similar to scenario 2, however after 20 years the total benefits were €19M lower showing that relying on the current number of GIBB herds to disseminate better stock bulls out into the industry was not as effective as getting the wider Gene Ireland AI usage through all pedigree herds.



Figure 5: The total benefits from genetics per year in €M for scenario 10: 30% usage of GIBB herd stock bulls in all pedigree herds, scenario 11: 30% usage of GIBB herd stock bulls in all pedigree herds plus 30% usage of Gene Ireland AI bulls in all GIBB herds

The scenarios from 13 to 16 looked at modifying the selection of the Gene Ireland AI candidates selected for progeny testing. Scenarios 13 and 13a removed the restriction that Gene Ireland progeny test candidates must come from GIBB herds, increasing the stage one selection pool, but with a lower accuracy of selection in stage one, 0.3 in 13 and 0.15 in 13a. Scenario 14 additionally allowed 3 star bulls to be selected in stage 1 along with 4 and 5 star bulls from any pedigree herd, but with the restriction that the same number were progeny tested. Opening up the pool of potential Gene Ireland candidates increased the total benefits by €1M after 10 years, compared to scenario 2 with the increased usage of Gene Ireland AI, however this increased to €9-11M more after 20 years. The effect of including 3 star bulls in the first stage of selection decreased the total benefits marginally. Scenarios 15 and 16 looked at selecting the Gene Ireland progeny test candidates using genomic selection from all pedigree herds, with genomic selection accuracies of 0.65 (scenario 15) and 0.75 (scenario 16). The higher accuracy of stage 1 selection added €2M over scenario 2 after 10 years, which increased to €21.8M in additional total benefits after 20 years with an accuracy of 0.65, and €23.3M with an accuracy of 0.75.



The last set of scenarios, 17, 18 and 19 looked at compounding favourable factors from previous scenarios with (scenario 17) and without genomics (scenario 18). Scenario 17 led to the highest total benefits, with €94M after 10 years, and €216M after 20 years, an increase of almost €160M over the base BDGP scenario. Compounding the favourable factors that did not involve genomics still led to higher total benefits than any of the scenarios modifying a single factor, with total benefits of €79M after 10 years and €176M after 20 years. Scenario 19 looked at an “ideal” scenario where 50% Gene Ireland AI was used in all pedigree herds, with the remaining bull usage split between GIBB and other pedigree herd stock bulls (20% and 10% respectively) and the remaining 20% coming from other Irish AI usage. Gene Ireland AI was set to 30% in commercial herds as well, with 20% other Irish AI, GIBB and other pedigree stock bulls, and the remaining 10% from foreign AI. Similarly, to scenario 17, Gene Ireland AI bulls were sourced from all pedigree herds with an accuracy of 0.75 and used at an earlier age. Scenario 19 led to total benefits of €118M after 10 years, which was €24M higher than scenario 17, and €307M after 20 years, showing that completely displacing foreign AI usage and using high proportions of Gene Ireland AI would be highly effective in improving the replacement index.



# Scaling to full industry

The benefits from the BDGP adoption scenario and the three scenarios looking at compounding favourable changes (17, 18 and 19) were scaled up to benefits from the full industry. This was done by scaling the number of expressions of the index up by 2.2, from 400,000 to 880,000, with the same levels of bull usage in pedigree and commercial herds as was used in the Limousin case study. Table 5 shows the total and annualised benefits from genetics for the full industry over 10, 15 and 20 years. The total benefits from each of the compounding scenarios were substantially higher than the base scenario of BDGP adoption after 20 years, ranging from 386.5 million euro from scenario 18 – compounding favourable changes without genomics to 674.4 million euro from scenario 19 where favourable changes were compounded with genomics and the bull usage was set to best possible levels.

Table 5: The total and annualised benefits in €M scaled up to the full industry for the base BDGP scenario and the three scenarios where favourable changes were compounded.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Total benefits (€M) | **Scenario 1** | **Scenario 17** | **Scenario 18** | **Scenario 19** |
| 10 years | 71.3 | 206.2 | 173.9 | 259.5 |
| 15 years | 103.1 | 349.4 | 286.9 | 473.5 |
| 20 years | 128.1 | 475.4 | 386.5 | 674.4 |
| Annualised benefits (€M) | | |  |  |
| 10 years | 10.2 | 29.4 | 24.8 | 36.9 |
| 15 years | 11.3 | 38.4 | 31.5 | 52.0 |
| 20 years | 12.1 | 44.9 | 36.5 | 63.7 |

# Commentary on results

The BDGP alone should deliver substantial industry benefits, even before genetic gains via improved selection of sires come in to effect. This is through smaller, more efficient, more fertile and milkier suckler cows.

Breeding strategies focused solely on GIBB herds have limited impact. There are just not enough of these herds, they are not selling enough stock bulls, and flows of genes from these herds are not a large factor in the overall flows of genes. Therefore, we need to find other ways of encouraging good recording than relying on the incentive of better recording herds being the focus on sourcing bulls for Gene Ireland progeny test.

The best returns came from wider usage of the Gene Ireland AI bulls within the pedigree and GIBB herds, with scenarios 2, 8 modelling 30% usage of Gene Ireland AI sires in GIBB and other pedigree herds per year. With around 8,000 calvings per year in pedigree herds, this level of usage would be equivalent to requiring around 4,000 straws of semen per year. The benefits were tested with levels of Gene Ireland AI usage between 5% and 30%, with each additional 5% usage resulting in an extra 1.3M in total benefits after 10 years and ~7.5M in total benefits after 20 years over scenario 1, where each 5% increase is around 670 extra straws of semen.

The challenge in increasing the usage of Gene Ireland AI sires will be changing farmer behaviour and reducing the reliance on foreign AI sires (70% of calvings in GIBB herds are from foreign sires) as each scenario that increased usage of Gene Ireland AI sires reduced the usage of foreign sires. This may be difficult, particularly if the foreign sires improve (scenario 9) as in the short term (first 10 years) a higher base of foreign sires did produce the highest benefits, however in the long term, increasing usage of the Gene Ireland program produced substantially higher benefits. In terms of the use of genomics, and whether this can be used to replace Gene Ireland progeny testing, the result indicates that to do this genomics would need to identify maternal bulls sufficiently accurately for them to be used widely by AI in pedigree herds (displacing foreign AI usage), and this can lead to substantial benefits over 20 years.

Greater sourcing of suckler herd replacements from the dairy herd will dilute down the long term impacts of genetic gains in beef breeds. This is because the genetic content of the suckler herd that traces back to dairy origin is not influenced at all by genetic gain in beef breeds. While dairy cross beef cows are currently higher on maternal index than suckler cow derived replacements, ongoing improvements in the maternal ability of beef breeds should reverse this over time. Ongoing improvement in the maternal beef merit of the genes flowing into the beef herd from the dairy industry is unlikely. So a better long term outcome for the suckler beef industry will come from an improvement in the maternal ability of the suckler herd, and consequently, the heifer replacements derived directly from these suckler cows.

While there would be gains from sourcing better foreign bulls, by using the genomic test from Ireland to screen candidates for importation, these benefits are not compounding. So while there is a short term lift, genetic improvement initiatives in Ireland are not feeding benefits back into the foreign schemes, which are likely to continue their current focus on terminal traits. Another key to maximising gains from beef breeding initiatives in Ireland is to displace the current reliance on foreign semen, particularly, the use of foreign semen in pedigree herds.

It makes sense to expand the pool of herds from which bulls are sourced for Gene Ireland progeny testing. The advantages of relaxing the selection criteria to 3, 4 or 5 star young bulls, instead of just 4 or 5 star bulls come through a broader pool of bulls to access, and in the short term, this might compensate for the lower genetic merit on average of the bulls entering the progeny test process. However, much greater gains will be realised when bulls are sourced to enter the Gene Ireland progeny test process based on genomic testing across as wide a pool of pedigree bulls as is practical and cost effective.

# Recommendations

1. That a wider pool of pedigree herds be used for sourcing candidates for Gene Ireland progeny testing, and that the selection process be enhanced through genomic testing of 3, 4 and 5 star (prior to genomic testing) candidates in all pedigree herds.
2. Other things being equal, preference should be given to sourcing bulls from GIBB herds, but young bulls with superior genomic test results from other pedigree herds should be considered for Gene Ireland progeny testing.
3. Additional selection criteria (factors other than maternal index) such as breeder reputation, physical type and soundness, and breed characteristics, that might limit the acceptability of semen generated from the young bull, remain critical selection criteria, and expanding the pool of source herds should assist with meeting these requirements while maintaining an ability to apply selection pressure based on maternal index.
4. Bulls with high reliabilities, and from well-connected herds (i.e. they regularly use sires that have been used by a number of other pedigree breeders or by multiple commercial farmers), be identified as being a safer bet to deliver future 4 and 5 star daughters. This should become the key method of incentivising improved data quality reporting.
5. When sourcing foreign bulls for domestic use, AI companies should be encouraged to first undertake a genomic test to predict the bulls maternal genetic merit in Ireland. The incentive will be that marketability of the bull in Ireland should be greatly enhanced by it having a high maternal index.
6. In addition to promoting high maternal index stock bull usage by suckler farmers, ICBF should also promote the direct use of high maternal AI sires into a subset of high maternal index cows to breed suckler herd replacements. The semen sexing option should be revisited in this light.
7. Pedigree breeders should be encouraged to counter the threat of displacement of their market for stock bulls by AI, by generating higher maternal index stock bulls, ideally through AI of high merit Gene Ireland progeny tested bulls into their pedigree herds. This would also improve connectedness, and therefore their herd data quality index.
8. Until a better pool of maternal bulls is available to commercial suckler farmers (through AI and/or pedigree bred stock bulls), ICBF should evaluate and demonstrate the short term gains from sourcing dairy cross replacements, when these dairy cross replacements have a higher maternal index then suckler herd derived equivalents. Many suckler derived replacements will currently outperform dairy cross replacements, and this will likely increase in the future if the breeding strategy is successful.

1. Implications of future industry structure for genomic selection strategies in Ireland – ICBF report by Fiona Hely and Peter Amer, 16th September 2014. [↑](#footnote-ref-1)