

Sources of Benefits from Genetic Improvement in the UK Dairy Industry and their Impacts on Producers and Consumers

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Abstract

Bull insemination records and Interbull genetic evaluation results for a very large number of elite dairy sires used globally since 1980 were used to quantify the benefits of genetic improvement in the UK dairy industry. The aggregate benefits of genetic improvement in the UK dairy industry are estimated to have been between **£2.2 billion and £2.4 billion since 1980**. Importation of superior gene stocks has played a substantial role in delivering these benefits, both directly from imported semen, and from use of this semen to breed UK born bulls of high merit. While the USA has contributed a large proportion of this imported genetic gain, Interbull results suggest that bulls from many other countries were of comparable or superior genetic merit for use in the UK, and that bulls first proven in the UK have been on a par with imported bulls for a number of years. There is also an indication that foreign proven bulls used in the UK in 2008 and 2009, were superior (for use in the UK) to the active bulls available from the source country. Future dairy industry benefits from this preferential identification of foreign bulls for import in 2008 and 2009 were estimated to be £8.3 and £15.3 million respectively. The likely sharing of benefits among farmers and consumers is discussed.

Introduction

The genetic merit of dairy cows and bulls in the UK is estimated using genetic evaluation procedures applied to herd performance recording data using genetic evaluation procedures similar to those used in many other countries throughout the world. The on farm economic benefits of genetic improvement have been studied extensively using sophisticated economic models (Santarossa *et al.*, 2004), and predictions of genetic improvement in individual traits can be aggregated into an overall economic benefit by multiplying genetic values for individual traits by formulated economic weighting factors. In the UK this is called the Profitable Lifetime Index (Wall, 2010).

Informed transfer of bull semen internationally is facilitated by international genetic evaluations that allow the genetic merit of bulls first proven in many different foreign countries to be compared with bulls tested and/or proven in a home country. This has created a globalised industry structure for provision of genetic improvement to commercial dairy farmers (Wickham and Banos, 1998).

The primary objective of this study was to quantify economic benefits from historic genetic improvement occurring in the UK. A secondary objective was to quantify the collective contribution of domestic genetic evaluation systems, research, and the benefit of having a UK specific selection index to the economic benefits of genetic progress.

Methods

Let u be the average genetic merit of UK Holstein and Friesian cows by year of birth for a genetic trait or index of interest. These breeds have more than 90% market share of UK semen sales. The average genetic merit of the average Holstein dairy herd for a trait denoted m in year l can be computed allowing for the lags from birth to year of expression using

$$m_l = \sum_{i=1}^n w_i u_{l-i-2} \quad (1)$$

where n is the maximum number of years of herd life accounted for and w_i is the proportion of cows in each age i assumed to be constant across all years of interest. This assumes a first calving age of two years.

The UK national index (denoted PLI) is computed by multiplying predicted transmitting abilities for traits of direct economic importance by an economic weighting factor expressed as expected pounds (£) of profit to farmers per cow per year per unit of the relevant PTA trait and summing the products. These values were either assumed to be held constant across years, or alternatively adjusted by the ratio of the real farm milk price in a performance year divided by the real farm milk price in 2007. Adjustment for the real farm milk price ratio allows for the fact that the economic benefits from genetic progress are strongly driven by the average milk price, and this is important because real farm milk prices were substantially higher historically than they are now.

The present value of industry net benefits from genetic improvement (NB) in the year in which merit is expressed and aggregated across cows (c) in year of performance i are computed as

$$NB_l = \left(\frac{1}{1+r} \right)^{l-a} c_l \cdot 2 \cdot (PLI_l - PLI_z) \quad (2)$$

where $PLI_l - PLI_z$ gives the superiority in the national index on a £/year base in year of performance i relative to a base year z where each PLI value is computed using equation (1) above. The multiplication by 2 in equation (2) accounts for the fact that the national PLI index values genes expressed in an offspring inheriting one half of the genetic merit of a parent. A discounting factor r is also included in equation 2 and this converts monetary values in lactation year l to a constant reference year denoted a . Present values of annual industry benefits can then be summed over production years of interest.

Aggregate net benefits were discounted by 7% to calculate the total present value of benefits from genetic improvement since 1980 realised up until the end of 2009. Alternatively, the annualised benefits for years one to five (AI^5) of genetic progress following some base level of genetic merit at year zero (NB_0) can be calculated as

$$AI^5 = \frac{\sum_{i=1}^5 NB_i - NB_0}{5!}$$

where NB_i is the industry value of genetic improvements in year i relative to any arbitrary base year..

The numbers of inseminations per year by bull identifier in the UK were obtained from UK records. Where offspring with sire IDs were available but no service information was recorded, a phantom service record was created. The second data source was a results file from the international Interbull genetic evaluation containing predicted transmitting abilities for traits included in the UK national index on the UK scale. Numbers of dairy cows

and the real farm milk price from performance years 1980 through until 2009 were sourced from industry statistics.

The interbull records made it possible to identify the average differential across countries between the PLI index of bulls used in the UK, versus all bulls under widespread mating in the same country. A bull was regarded as having undergone widespread mating in an exporting country if it had more than 500 recorded daughters in that country. Differences between imported bulls versus those more widely available from the exporting country were quantified using PLI estimates from interbull results files on the UK scale.

Results

Using static PLI weightings, the aggregate benefits from dairy cattle genetic improvement in the UK from 1980 until 2009 were calculated to be **£2.19 billion**. With PLI weightings updated by year based on the real milk price relative to 2007 and translated to 2010 currency values, total benefits were found to be **£2.42 billion**.

The average annualised incremental benefit was **£9.1 million** if averaged over all of the years between 1980 and 2009. The highest 5 year rolling average equivalent occurred between 1990 and 1994 where rates of progress in PLI were high and cow numbers relatively static. For this period, the annualised incrementing amount of benefit was **£15.8 million**, while for the most recent 5 year period (2004-2009) the annualised incrementing benefit was **£7.4 million**.

Up until approximately the bull birth year of 2000, there was a tendency for the merit of bulls used in the UK to be at or below the average genetic merit of highly used bulls from the country where the imported semen

originated. In contrast, bulls with a birth year of 2000 or later, tended to be of higher merit than the average of those available from the same country. An exception to this in the more recent period is the merit of bulls from France. It should be noted that numbers of bulls born in 2004 were quite low for many of the countries at the time data was accessed (2009). The data available from Interbull made it possible to compare the merit of imported bulls with the average merit of all bulls available in widespread use from the same country. Figure 1 shows the weighted (by percent inseminations from each country in each year) average differential across countries between the PLI index of bulls used in the UK, versus all bulls under widespread mating in the same country. Country specific values for the USA and Canada are also shown as these countries were significant sources of foreign proven bulls used in the UK. On average, the differential of UK imported bulls over those available has tracked at or slightly below zero until 2008 and 2009, where more suitable bulls based on the current PLI have been sourced. The PLI index used in the UK was updated in 2007 with an increase in emphasis on functional traits.

Discussion

The aggregate benefit of genetic improvement in the UK since 1980 is huge and must vastly outweigh the investment in semen purchase, genetic evaluation systems development and operation. Importation of superior gene stocks has played a substantial role in delivering these benefits, both directly from imported semen, and from use of this semen to breed UK born bulls of high merit. Effectively, the process of importation has involved upgrading traditional British Friesian dual purpose (milk and meat) cattle to a more specialised dairy animal with very high levels of milk production per cow.

While the USA has contributed a large proportion of this imported genetic gain, Interbull results suggest that bulls from many other countries are of comparable or superior genetic merit for use in the UK, and that bulls first proven in the UK have been on a par with imported bulls for a number of years.

There is also an indication that bulls used in the UK, as of relatively recently, are being actively sourced as being superior to the main bulls available from the source country (Figure 1). This may well reflect the divergence in breeding goals with a greater emphasis on fertility and functional traits in the UK index. Benefits from this preferential identification of foreign bulls for import were estimated to be at least £8.3 and £15.3 million in 2008 and 2009 respectively.

Support, development and maintenance of performance recording and genetic evaluation infrastructure allows the UK to contribute to the collective global effort for improvement in the genetic merit in dairy cattle which in turns contributes to lower milk prices for consumers around the world. While high rates of genetic progress in UK dairy cattle would have been achieved from importation in the absence of infrastructure for genetic evaluation and without a national breeding index such as the PLI, it is highly unlikely that the importation process would have been as efficient as that which has been observed. Thus, a substantial opportunity for further cost reductions in the UK dairy industry would be placed at risk if this genetic improvement structure of performance recording and genetic evaluations was not maintained. This same structure also provides future opportunity to add new traits and influence the direction of genetic progress

to meet specific requirements of the UK industry and markets.

It is unclear whether long run benefits from reductions in dairy farm costs due to genetic improvement have been captured by UK farmers or by UK consumers. While consumer milk prices in the UK have dropped in conjunction with on-farm efficiency and processing improvements, fluctuations in UK farm gate milk prices follow closely fluctuations in international commodity prices. This suggests that prices may have dropped, irrespective of whether or not farmers have made efficiency gains. If so, then UK dairy farmers are most likely substantial beneficiaries of these genetic improvements. Without genetic improvement, it is highly unlikely that a viable dairy industry could still exist in the UK. UK Consumers of fresh fluid milk have therefore also benefited from genetic improvement, as supply would have been either limited and/or very expensive in its absence.

References

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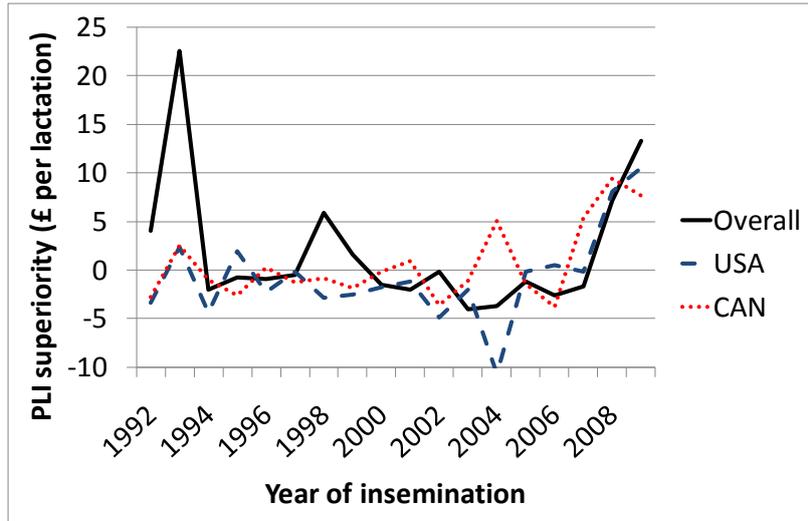


Figure 1. Superiority for PLI of bulls used in the UK versus those under widespread use in the source country.