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Economic comparison of Holstein-Friesian strains

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ABSTRACT

The objective of this research was to identify major determinants of net profit per cow. Data were from the Dexcel strain trial over three seasons, in which Holstein-Friesian cows were managed in groups of 12 to 20 cows in eleven farmlets. Milk returns were calculated from lactation yields of milk, fat and protein. Net profit per cow was calculated as the net return from milk sales plus sales of calves minus feed, fertility, health, shed and working expense costs. Annualised present values were derived using asset replacement theory and discounting to account for different numbers of years of data according to the year in which an animal entered the herd. Net replacement costs and average replacement returns were included where animals were replaced before the end of the trial. Partition analysis was used to identify indicators of cow profitability. Partition analysis recursively sub-divides data creating a tree of partitions. Each split is chosen to maximise the difference in profitability between branches of the split. Variables on which data could be partitioned included breeding values, Breeding Worth and traits measured in first parity. The key determinants of profitability were lactation yield of protein and fat, percentage of fat and Breeding Worth. When these variables were fitted to a multiple regression model where the response was annualised present value, the adjusted R^2 was 52%.

Keywords: asset replacement model; economics; dairy cattle.

INTRODUCTION

The Dexcel Holstein-Friesian Strain trial was established to investigate the physical and financial performance of three strains of Holstein-Friesians managed in a range of New Zealand (NZ) pasture-based systems which differ in stocking rate and use of supplementary feed.

Farris (1960) developed replacement models for cattle fattening, forestry and orchard enterprises and this approach has been applied to NZ dairy cattle by Harris (1987). The method is known as the asset replacement model. The purpose of these models is to aid replacement decisions through marginal net revenues discounted through time and using all information (e.g. multiple streams of income from several lactations of production). Aplin (1981) suggested using annualised present values (APVs) to overcome the problem of varying lifespans. Thus, decisions to replace animals with the lowest APVs can be made.

APVs were calculated using data from the Dexcel Holstein-Friesian Strain Trial over three years and included culling costs. The aim of this study was to use income streams from varying numbers of years (3 years for cows entering the herd in 2001 to one year of data for cows entering the herd in 2003) to calculate a single APV per cow in a way that accounts for culling and adjusts revenue and cost streams to a single financial base. This is one way in which data from all seasons can be used simultaneously and provide a value of per cow profitability. The APVs can be used to 1) compare performance of strains 2) compare performance of farmlets and 3) identify key variables available in the first lactation that can aid identification of the most profitable cows.

MATERIALS AND METHODS

Data were from the Dexcel Strain Trial (2000/2001 to 2003/2004). Details of the trial are given by Harris *et al*. (2003), Macdonald *et al*. (2005) and Pryce *et al*. (2005). Net income (NI) per annum per cow was calculated as returns from milk and calf sales minus feed, health, fertility, shed, labour and working costs per cow.

Returns

Milk returns per cow were calculated using the mean milksolids payout over the years of the trial, expected national fat to protein price ratio and current volume charge. The mean payout was used to avoid fluctuations due to the price of milk. The derived prices were: $2.86 per kg milk fat, $7.59 per kg protein and $-0.0397 per litre of milk volume.

Calf fates were recorded as reared, bobbied or sold. Sold and bobbied were classified as bobbied and the income from the sale of calves calculated as $2/kg of live weight of the calf. The income from bobby calf sales was shared between cows, as the probability of a heifer birth is a chance occurrence. Therefore, an overall return from calf sales was calculated per farmlet-season

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from the number of live calves born minus 30% kept for replacements.

Cull cow costs were calculated assuming a killing out percentage of 45%. Mean carcase weights (by strain-season) ranged between 201.5 kg and 251.3 kg. Average NZ meat schedule values were applied, recognising the higher price per kilogram for carcase weights greater than 220 kg.

Costs

Replacement costs

A standard charge of $732 per Holstein-Friesian replacement was assumed (IRD, 2004) and includes feed and rearing costs.

Feed costs

Feed costs were calculated per farmlet by season as the summation of pasture silage harvesting costs ($0.15/kg DM), maize silage costs ($0.22/kg DM), fertiliser costs ($0.25 for 0.8 kg of 20% potassium fertiliser per kg MS), nitrogen fertiliser ($0.80/kg applied) and topping ($20/ha). The feed costs were divided between cows within each farmlet according to the amount of feed eaten per cow. Intake per cow was approximated using equations to predict metabolisable (ME) requirements for production, maintenance and pregnancy as described by Pryce *et al*. (2005). Thus, feed costs per animal were calculated as: $\$FC_f \frac{ME_i}{ME_f}$ where $\$FC_f$ are feed costs per farmlet-season, ME_i is the ME intake of cow i and ME_f is the mean ME intake of the farmlet-season.

Health costs

The number of treatments per cow per season was calculated by counting the total number of times a cow was recorded as being treated for a particular disease (mastitis or lameness) in a season. The number of cases was defined as the number of treatments that could be considered as independent occurrences of disease (which differs depending on the disease). For mastitis the cost was calculated as $10 labour + $12 antibiotics + $ of discarded milk. The cost of treating lameness was calculated using the results of a lameness survey published in the Dairy Exporter in April 2004 as $26.34 per case and $12.40 in treatment costs = $38.74. Generally the types of drugs used for treating lameness in this trial required no milk disposal.

Fertility costs

Anoestrus treatments were charged at $27 per treated cow. Artificial breeding costs were charged at $14 per insemination.

Shed costs

Calculated to be $0.19 per cow per day milked. This is broken down to $0.08 per day of shed expenses and $0.11 of electricity costs.

Labour and working expenses

Labour costs were assumed to be a flat rate of $128 per cow (Dexcel Economic Survey, 2002) taken from a survey of 208 farms. Working expenses included freight, weed and pest control, repairs and maintenance, vehicle costs, administration and standing charges which were assumed to cost the same per hectare ($676/ha). As the stocking rate varied between farmlets, these per hectare costs were lower on a per cow basis for higher stocked herds. Details of farmlets and stocking rates etc. are in Macdonald *et al*. (2005) and Pryce *et al*. (2005).

Present values

Present values (PV) were calculated using the calculated net incomes (NI) per cow-season as described above. The economic analysis used in this study had three main attributes. 1) It accounted for multiple time periods. This was important as some cows had three years of data whereas others had only one year of data. Thus each animal had a single PV regardless of its number of years of data. 2) Discounting was used to make an adjustment for future returns versus current returns. 3) It accounted for culling and replacements. If an animal was culled in its first lactation and three years of data were possible, then the remaining two years of data were calculated as mean yields of replacement animals (described in Equation 1). Replacement costs were charged only if the animal was replaced. Data on 270 cows were used to calculate PVs. In total 567 lactation records were used over three years.

When an asset generates net returns in each of a number of future years, time value of money can be accounted for by applying a discount factor (β) to discount future revenues to their present value in a base year. The discount factor is: $\beta = \frac{1}{1+i}$ where i is the interest rate (assumed for this study to be 6%).

Cows that entered the herd in 2001 had three possible states: 1) complete one lactation (Equation 1), 2) complete two lactations (Equation 2), or 3) complete three lactations (Equation 3).

Where $NI_{i,1}$ is the net income of cow i in season 1 (2001), $cullValue_{1,1}$ is the cull value of a cow in lactation 1 in season 1, RC is the replacement cost, which is assumed to be the same across years and strains and is $732. $PrCull_{1,1}$ is the probability of a cow in lactation 1 being culled in season 1.

Equation 1:

$$PV_i = (NI_{i,1} + \overline{cullValue}_{1,1} - \overline{RC}) +$$
$$(\beta((\overline{NI}_{1,2} + \overline{cullValue}_{1,2} - \overline{RC})\Pr Cull_{1,2}) +$$
$$(\overline{NI}_{1,2} * (1 - \Pr Cull_{1,2}))))$$
$$+ (\beta^2((\overline{NI}_{2,3} + \overline{cullValue}_{2,3} - \overline{RC})(\tfrac{1}{2}\Pr Cull_{2,3}) +$$
$$(\overline{NI}_{2,3} * (\tfrac{1}{2}(1 - \Pr Cull_{2,3})) +$$
$$(\overline{NI}_{1,3} + \overline{cullValue}_{1,3} - \overline{RC})(\tfrac{1}{2}\Pr Cull_{1,3}) +$$
$$(\overline{NI}_{1,3} * (\tfrac{1}{2}(1 - \Pr Cull_{1,3})))))$$

Equation 2:
The PV for a cow in state 2 is calculated as:

$$PV_i = NI_{i,1} + (\beta(NI_{i,2} + \overline{cullValue}_{2,2} - \overline{RC}))$$
$$+ (\beta^2((\overline{NI}_{1,3} + \overline{cullValue}_{1,3} - \overline{RC})\Pr Cull_{1,3} +$$
$$(\overline{NI}_{1,3}(1 - \Pr Cull_{1,3}))))$$

Equation 3:
The PV for a cow in state 3 that was not culled at the end of her third lactation was calculated as:

$$PV_i = NI_{i,1} + \beta NI_{i,2} + \beta^2 NI_{i,3}$$

Equation 4:
The PV for a cow in state 3 that was culled at the end of her third lactation was calculated as:

$$PV_i = NI_{i,1} + \beta NI_{i,2} + (\beta^2 NI_{i,3} + \overline{cullValue}_{3,3} - \overline{RC})$$

The same principle was applied for cows that entered the herd in 2002 and 2003, except there were two possible states for cows that entered the herd in 2002 and one possible state for cows that entered the herd in 2003.

Annualised present value (APV)

The annualised present value (APV) was calculated as the present value for each cow multiplied by the amortisation factor (AMF), where

$$AMF = \frac{i}{1-(1+i)^{-n}}$$ and n is the number of years over which the returns are received.

Partition analysis

The characteristics that could be used to identify the most profitable cows were investigated using partition analysis in JMP (SAS, 2004) to identify the key drivers, followed by a multiple regression model that included the most important characteristics as identified by the partition analysis as explanatory variables for APV. Partition analysis recursively sub-divides data creating a tree of partitions. Each split is chosen to maximise the difference in the responses between branches of the split; the most significant split is determined by the largest likelihood-ratio chi-square statistic. Variables on which the data could be partitioned included first parity lactation average live weight, condition score, somatic cell score, milk, fat, protein and lactose lactation yields and percentages, lactation length, breeding values, breeding and lactation worth, Holstein percentage, culling reasons, cases of disease and pregnancy rate in the first six weeks. First lactation yields of milk, fat and protein were on average lower in 2001 than the other two years of the strain trial. Parity-season effects (mean and variance) were removed from traits and the resultant residuals standardised. Standardised residuals have a mean of zero and standard deviation of one. Thus, contemporary group is accounted for and animals with the most and least desirable attributes per contemporary group could be identified. The standardised residuals were abbreviated as ResMY, ResFY, ResPY, ResLY for residual milk, fat, protein and lactose yields, ResFP, ResPP, ResBCS, ResLWT, ResSCS, ResLL for standardised residual fat percentage, protein percentage, body condition score, live weight, somatic cell score and lactation length.

TABLE 1: Summary statistics of APVs of three strains of cows by year of entry into the herd.

Strain	Entered herd	Max ($)	Min ($)	Mean ($)	SD ($)	n
NZ90	2001	1545	810	1156	192	68
	2002	1598	739	1225	212	20
	2003	1607	918	1207	185	19
NZ70	2001	1383	271	910	217	36
	2002	1210	646	941	183	12
	2003	1214	650	944	169	12
OS90	2001	1632	525	1024	197	67
	2002	1546	752	1109	194	19
	2003	1416	803	1108	189	17

RESULTS

Summary statistics of APV by year and by strain are presented in Table 1. The mean APVs of the NZ90 strain were higher than the other two strains, the overall means being between \$124 per cow greater than the OS90s strain and \$255 per cow greater than the NZ70s strain (these differences were statistically significant $P < 0.001$). Variation between animals within strain was reasonably consistent (SD). A statistical comparison of APVs by season of entry into the herd (nested within strain) using a linear model in JMP (SAS, 2004) showed that there were no significant differences in APVs between seasons. Thus, adjusting APVs by season of entry into the herd was not warranted.

Forty two per cent of the NZ90 strain were in the top quartile of APV values (Table 2). The bottom quartile were predominantly NZ70 strain cows, with approximately half of the NZ70s cows in this quartile, the OS90 strain dominated the middle quartiles.

TABLE 2: Breakdown of strains by APV quartiles, where 1 is the highest quartile on APV.

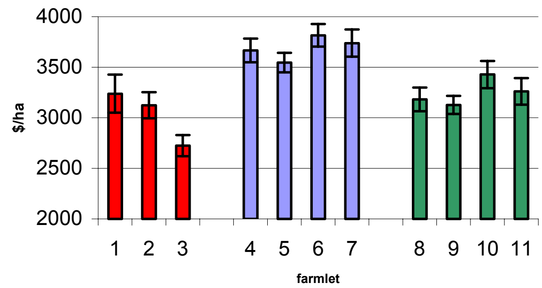
	Quartiles			
	1 (highest APV)	2	3	4 (lowest APV)
NZ90	41%	26%	23%	8%
NZ70	3%	22%	28%	47%
OS90	19%	26%	25%	29%

The stocking rate of each farmlet was 3.09 cows/ha except for farmlets 1 and 4 that had 3.71 and 3.29 cows per hectare. The mean APV per hectare per farmlet is presented in Figure 1. Within the NZ70s strain, the APV of farmlet 3 was significantly less than the APV of farmlet 1 or 2. This demonstrates that extra feeding of the NZ70 genotype is not economically worthwhile. There is no difference between feeding systems in the NZ90s strain, indicating that this strain maintains profitability on all levels of feeding. Extra feeding is thus recouped through matched extra production. The OS90s strain had consistent levels of profitability over the first three feeding levels (5.5 t, 6 t, 6.5 t) and a lower level of profitability at 7 tDM/cow offered. Strain means per hectare were significantly different between strains and were \$3691.72 for NZ90s, \$3029.45 for NZ70s and \$3250.30 for OS90s. The difference between NZ90s and NZ70s is \$662.27, which is bigger than the difference in Economic Farm Surplus figures calculated by Dexcel using Strain Trial data (\$530 per ha for 2003/2004 season) (Kolver *et al*., 2003).

In the partition analysis, protein yield was the key driver of profitability. Cows in the top 45% for (standardised) protein yield in their first parity generated \$260 more profit per cow per year than the bottom 55% for protein yield. The next level of partitions were also on individual cow production characteristics.

A linear regression of \$APV on standardized residual for protein yield (ResPY) has an adjusted R^2 of 45%. Including yield and percentage of fat as additional explanatory variables to protein yield increased the R^2 to 52%, with all variables included in the regression being significant ($P < 0.01$). Fitting BW to APV explained 29% of the variation in APV.

FIGURE 1: APV per hectare of the 11 farmlets (1-3: NZ70; 4-7 NZ90; 8-11 OS90)

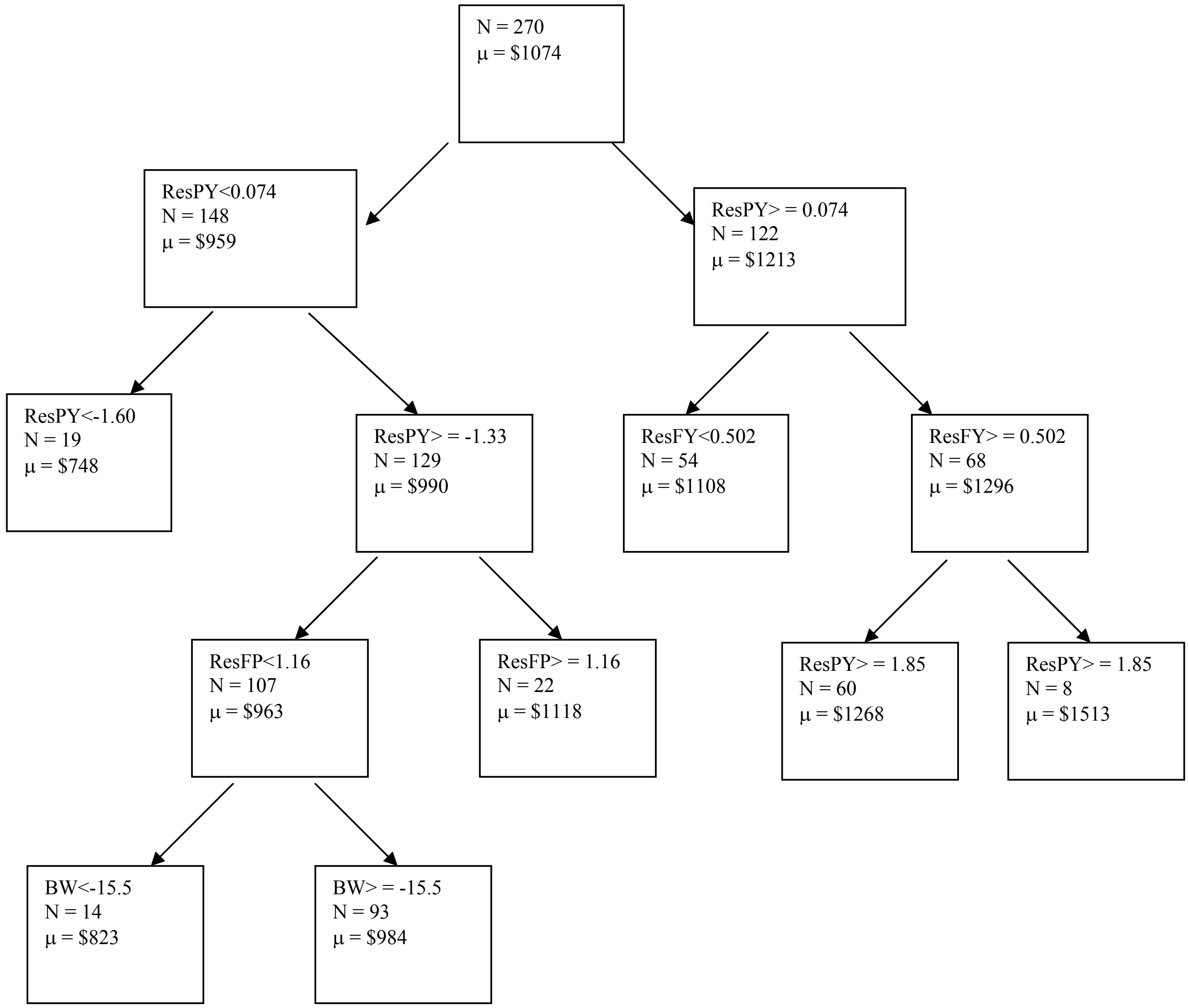


DISCUSSION

Using APVs allows comparisons to be made when income streams come from varying numbers of years. An APV can be considered as a weighted average of net returns with time taken into account. For cows entering the herd in 2001, the APV was based on three years of data. This group of cows not only had 1st lactation information, but also 2nd and 3rd lactation records contributing to their APV (more mature and thus more valuable lactations). However, 2-year-old milk production was lower in the first season of the trial than the other two years, which is why the APVs were similar across seasons.

Partition analysis is a good exploratory tool, when the key drivers influencing a trait are unknown. The partition analysis identified that protein yield had most power in splitting the data into cows of high and low APV. This was confirmed by the regression analysis of APV on protein yield, with about 45% of the variation in APV being explained by protein yield. BW explained around 29% of the variation. The mean reliabilities of the cows' BWs were 52%, thus from the BWs would be expected to explain 52% of the variation in profitability. The calculation of APV is not the same as BW, thus it is not surprising that the adjusted R^2 of the regression of APVs on BW is lower than the reliability of BWs. From a biological perspective, first parity yields of protein and fat were the most important predictors of APV. This is expected as milk sales are used in the calculation of APV. However, this still holds for animals that entered the herd in 2001, where first parity yield contributes to approximately one third of the milk production returns (e.g. a smaller part of the APV).

FIGURE 2: Partition analysis of APV of 270 cows from three genetic strains using explanatory variables (R-squared 54%).



Abbreviations: ResMY, ResFY, ResPY are standardised residual milk, fat and protein yields, ResFP is standardised residual fat percentage; BW: Breeding Worth.

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