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Sensitivity Analysis of Relative Net Income of Iranian Holstein Cows to Prices

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Abstract: In this investigation lifetime performance records for 4633 Holstein cows in northwest of Iran, with opportunity for up to 8 freshening, were used to study lifetime Relative Net Income (RNI) and Relative Net Income Per Day of productive life (RNIPD). A sensitivity analysis was performed in order to determine the relative impact of milk price, feed and non-feed costs on RNI and RNIPD. Total actual milk production had the highest correlation with RNI and RNIPD (0.97 and 0.67, respectively). There were negative correlations between milk fat percentage and RNI and RNIPD which were the consequences of low price for milk fat in the population under study. Negative correlation was found between RNI and RNIPD with age at first freshening. Generally, correlations of studied variables except first lactation milk production with RNI were higher than their correlations with RNIPD. Changes in prices affected the means for RNI and RNIPD dramatically. Increasing the milk price and decreasing the costs resulted in raising means and standard deviations of RNI and RNIPD. The mean of RNI and RNIPD were increased by 2.6 and 2.78% as a result of 1% increase in milk price. Increasing feed and non-feed cost prices caused decreasing RNI and RNIPD. RNIPD was more sensitive to price changes than RNI. Milk price has the most important impact on RNI and RNIPD and then stand feed cost and non-feed, respectively. Correlations between RNI measured in different situations simulated by altering prices were above 0.99. The same trend was observed for RNIPD. Altering the prices had little effect on relationships between various profits functions measured in different situations. Changes of unit prices had little effect on the rank of cows according to their lifetime profit. It was also concluded that RNI and RNIPD were relatively resistant to any effect of possible mistakes due to improper economic assumptions as far as cow ranks are concerned. Correlation between RNI and RNIPD was high (0.79). Examining the result of altering the unit price of different economic items showed that raising the milk price would compensate any unfavorable result of increasing cost prices (feed and non-feed costs) and consequently could stabilize the mean life time profit of a population.

Key words: Relative net income, price changes, productive traits, dairy cattle

INTRODUCTION

The breeding goal for dairy cattle is to increase economic merit of cows. In addition to milk yield, there are several traits which affect economic efficiency of cows (Norman and Powell, 1999). Use of a profit function is a common way to measure economic efficiency of dairy cattle. Balaine *et al.* (1981) used actual income and expense data from a research dairy herd and compared some types of their (linear and non linear) combinations. According to their results, the use of linear function of income and expense (i.e., profit equation) is adequate in studies on the economic aspects of lifetime performance of dairy cattle.

Actual expense and income data are quite limited in commercial dairy herds, leading to a need to use some estimates of profit from field data. Norman *et al.* (1981) introduced a profit function called Relative Net Income (RNI), which was designed to reflect major differences among dairy cows in respect to income and expense variables.

RNI had been realized as a useful response variable for studies involving performance traits measured early in life (Cassell and Weigel, 1994).

Tigges *et al.* (1984) studied the impact of different variables which are measurable in commercial farms on RNI. They concluded that milk yield was the most important variable in RNI. The value of produced milk and the length of herd life accounted for 94% of the variation in RNI.

RNI of a cow is a function of lifetime performance records and also the unit prices of input and output in production system. However, income and expense levels are subject to various factors affecting production system

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and therefore, would be changed over time. These changes would cause changes in the RNI estimates of cows.

Balaine *et al.* (1981) used estimated prices representing three points over 15 years to calculate three kinds of lifetime profit measure for each cow. The correlations among measures of profit were higher than 0.98. They concluded that the large variance in changes of various unit prices had little effect on rank of cows on lifetime profit.

Beaudary *et al.* (1988) studied the impact of prices on profit functions. They used different combinations of income and expense factors to estimate RNI for Holstein cows. Correlation between different estimates of RNI exceeded 0.90 in most combinations. They suggested it is not likely that major conclusions from studies involving RNI would be affected by reasonably accurate economic assumptions.

The various economic variables differ in the magnitude of their impact on RNI. Neither Balaine *et al.* (1981) nor Beaudary *et al.* (1988) did not show which economic variable had an overriding importance. Therefore a kind of sensitivity analysis is necessary in studies about RNI.

The objective of this study, was to study on RNI and RNI Per Day of life time (RNIPD) of Holstein cows in northwest of Iran and perform a sensitivity analysis in order to determine the relative importance of different economic variables.

MATERIALS AND METHODS

Lifetime performance records of 4633 Holstein cows in northwest of Iran were used in this study. All cows with opportunity up to 8 freshening were entered and cows with calving interval less than 295 day were excluded from data set.

The RNI for each cow was determined by the following equation (Shadparvar, 1999):

$RNI = T_M(r_M - c_M) + NF(r_F - c_F) + r_c - NI(c_I) - DPL(c_f) - AFF(c_r) - G_1(c_{G1}) - G_2(c_{G2}) - IC$,

Where:

T_M = Total actual milk
r_M = Milk price
c_M = Feed and non-feed cost per kg milk
NF = Number of freshening
r_F = Calf price
c_F = Pregnancy feeding cost
r_c = Culled cow value
NI = Total number of insemination
c_I = Insemination cost

Table 1: Unit prices of variables at base situation

Price (US$)	Variable
0.717	Daily maintenance feed and non-feed cost
0.036	Feed and non-feed cost per kg milk with 3.2% fat
$4.61*10^{-4}$	Feed cost per additional gram of milk fat
0.095	Daily feed cost for growth in first lactation
0.047	Daily feed cost for growth in second lactation
8.549	Pregnancy feed cost (other than the first time)
6.474	Pregnancy feed cost (the first time)
0.769	Heifer rearing daily cost
7.222	Insemination cost
0.144	Milk price
94.444	Calf price
443.333	Culled cow value

DPL = Days of Productive Life
c_f = Daily maintenance feed and non-feed cost
AFF = Age at First Freshening
c_r = Heifer rearing daily cost
G_1 = Length of first lactation (day)
c_{G1} = Daily feed cost for growth in first lactation
G_2 = Length of second lactation(day)
c_{G2} = Daily feed cost for growth in second lactation
IC = The same as calf price

The following equation was used for computing c_M:

$$c_M = b + (t * s),$$

Where b is the feed and non-feed costs per kg milk with 3.2% fat; t is the cost of one additional percent of milk fat and s is the difference of milk fat percent from 3.2. To calculate RNIPD for a cow, its RNI was divided by its DPL.

Cost and income values are shown in Table 1. They represent main aspects of dairy farming in population under study at year 2000 and were considered as base situation in this study.

Simple correlations between each of different performance variables including Age at First Freshening (AFF), milk production in the first lactation, total actual milk, fat percent, number of freshening and Days of Productive Life (DPL), with both RNI and RNIPD were estimated.

Some sensitivity analysis were performed to examine the effect of milk price, feed and non-feed cost on RNI and RNIPD. In each analysis one variable was changed by ±10% with respect to its corresponding value at base situation, keeping all other variables constant. Therefore, six alternative situations have been simulated. At each situation RNI and RNIPD were calculated for each cow. Correlation coefficients between different measures of profitability were estimated.

RESULTS AND DISCUSTION

Means, standard deviations and ranges of performance variables are shown in Table 2. Average total actual milk in productive life was 21346 kg and was

Table 2: Means, Standard Deviations (SD), minimum and maximum values of performance variables for 4633 Holstein cows

Maximum	Minimum	SD	Mean	Variables
110757	251	13328	21346	Total actual milk (Kg)
5.18	2	0.348	2.668	Fat %
8	2	1.73	4.01	Number of freshening
1486	469	106.36	767.30	Age at first freshening (day)
3998	300	751.88	1545.71	Days of productive life (day)
10508	1879	1564	3919	First lactation milk production (Kg)

Table 3: Correlations between Relative Net Income (RNI) and RNI Per Day (RNIPD) with performance traits*

RNIPD	DPL	AFF	NF	Fat %	First lactation	Milk production	Total actual milk
RNI	0.7929	0.7255	-0.0458	0.8104	-0.0732	0.1654	0.9705
RNIPD*	1.0000	0.2863	-0.1624	0.4592	-0.1952	0.3603	0.6693

Fat%= milk fat percentage, NF = Number of Freshening, AFF= Age at First Freshening, DPL= Days of Productive Life

slightly larger than estimates in the literature (Tigges *et al*., 1986; Beaudry *et al*., 1988). Mean for fat percent was 2.7 and was smaller than that reported by Shadparvar and Yazdanshenas (2005) for Iranian Holstein population.

In the population under study, average number of calving was 4 and was slightly larger than that in other reports (Tigges *et al*., 1986; Beaudary *et al*., 1988). Mean AFF was 767.3 days and varied from 469-1486 days which was smaller than 840 days reported by Sadparvar and Yazdanshenas (2005). Mean DPL was 1546 days which was grater than those reported by others (e.g., 1010, 1060, 735 days reported by Tigges *et al.* (1986), Beaudry *et al.* (1988) and Cassell *et al.* (2002). Average first lactation milk production was 3919 kg and is much smaller than 7082 kg reported by Sadparvar and Yazdanshenas (2005).

Estimated correlation coefficients of RNI and RNIPD with measures of performance traits are depicted in Table 3. Total actual milk production had the highest correlation with RNI and RNIPD (0.97 and 0.67, respectively). The estimates in this study were close to those reported by Norman *et al.* (1981). They found that the correlations of RNI and RNIPD with total milk yield were 0.95 and 0.69, respectively. Cassell *et al.* (1993) estimated the correlation of RNI with total milk as 0.96. Other reports indicated that milk production is the most important factor affecting RNI variation (Visscher and Godoard, 1995; Pérez-Cabal and Alenda, 2003).

Correlations of RNI and RNIPD with first lactation milk production were 0.17 and 0.36, respectively. In de Hann *et al.* (1992) the correlation of RNI with first lactation milk yield was higher (0.47 and 0.52 for grade and register cows, respectively).

Correlations of number of freshening and DPL with RNI were high (0.81 and 0.73, respectively). These results agreed with those of other studies (Norman *et al*., 1981; Tigges *et al*., 1984; Beaudry *et al*., 1988).

RNI and RNIPD had negative correlation with milk fat percentage. Low price for milk fat in Iran is the most probable reason for its negative correlation with profit.

Negative correlation was found between RNI and RNIPD with AFF as it was in Cassell *et al.* (1993). A heifer has no milk and fat production during its rearing time and thus AFF could be known as a cost variable. Hence increasing AFF would result in more expense and reduction in RNI.

Correlations of studied variables except first lactation milk production with RNI were higher than their correlations with RNIPD. The correlation of first lactation milk production with RNIPD was 0.36. Calculating RNIPD through dividing RNI to DPL reduced the magnitude of the impact of lifetime variables and this is the reason for its smaller correlations with lifetime performance traits.

The means and standard deviations of RNI and RNIPD at base situation and at the situations resulted from changed prices are shown in Table 4. Changes in prices affected the means for RNI and RNIPD dramatically. Means for RNI and RNIPD in base situation were US$1204 and US$0.7, respectively. Increasing the milk price and decreasing the feed and non-feed costs resulted in higher means (US$1512, US$1391 and US$1271, respectively) and standard deviations of RNI compared with those values obtained in base situation. The same trend was observed for RNIPD. Reduced milk price and increased costs led to opposite results.

The results showed that the mean of RNI and RNIPD would increase by 2.6 and 2.78% per each percent of increase in milk price. It was revealed that one percent increase in feed and non-feed cost prices would cause a decrease of 1.56 and 0.56% in RNI and 1.86 and 0.67% in RNIPD, respectively. Comparison between changes in RNI and RNIPD revealed that RNIPD was more sensitive to price changes than RNI.

As it is obvious from Table 4, different rates of changes in mean RNI and RNIPD were observed at different situations. This implies that there is difference between magnitudes of the impacts of various factors of production system on profit functions. Milk price is the most important factor and feed cost is more important than non-feed costs. Examining the costs of production

Table 4: Means ($) and Standard Deviations (SD) of life time Relative Net Income (RNI) and Relative Net Income per Day (RNIPD) for 4633 Holstein cows in various situations

RNIPD		RNI		
SD	Mean	SD	Mean	
0.55	0.70	1116.85	1203.56	Base
0.54	0.57	1051.61	1015.84	10% increase in feed cost
0.55	0.83	1183.32	1391.29	10% decrease in feed cost
0.61	0.90	1304.51	1511.88	10% increase in milk price
0.48	0.51	931.18	895.24	10% decrease in milk price
0.55	0.65	1096.43	1136.12	10% increase in non-feed cost
0.55	0.75	1137.47	1271.00	10% decrease in non-feed cost

Table 5: Correlation between the different relative net income functions on a lifetime (above diagonal) and per day of production life (below diagonal) basis*

RNI (-N)	RNI (+N)	RNI (-M)	RNI (+M)	RNI (-F)	RNI (+F)	Base	Situation
0.9999	0.9999	0.9988	0.9994	0.9995	0.9994		Base
0.9988	0.9998	0.9999	0.9975	0.9978		0.9987	RNI (+F)
0.9998	0.9990	0.9967	0.9999		0.9950	0.9988	RNI (-F)
0.9997	0.9987	0.9963		0.9996	0.9972	0.9996	RNI (+M)
0.9980	0.9993		0.9981	0.9968	0.9996	0.9994	RNI (-M)
0.9996		0.9998	0.9990	0.9977	0.9995	0.9998	RNI (+N)
	0.9993	0.9987	0.9999	0.9995	0.9976	0.9998	RNI (-N)

*RNI(+F)=RNI resulted from increasing feed cost by 10%, RNI(-F)=RNI resulted from decreasing feed cost by 10%, RNI(+M)=RNI resulted from increasing milk price by 10%, RNI(-M)=RNI resulted from decreasing milk price by 10%, RNI(+N)=RNI resulted from increasing non-feed cost by 10%, RNI(-N)=RNI resulted from decreasing non-feed cost by 10%

system shows, the feed cost prices are larger than non-feed cost and this is the main reason for the larger sensitivity of profit functions to feed cost prices.

Correlation between the different measures of RNI and between the different RNIPD are shown in Table 5. Correlations between different RNI measures were almost always above 0.996. Altering the prices appeared to have very little effect on relationships between various RNI measured in different situations. These results correspond with the findings of other studies (Balain *et al*., 1981; Beaudry *et al*., 1988).

It could be concluded that changes of various unit prices had little effect on rank of cows on lifetime profit. Therefore it is expected that the rank of individual cows in a population according to their RNI measures would not change dramatically in the consequence of price changes in production system. Therefore, the concerns of dairy cattle breeders about genetic evaluations for lifetime profitability seem unwarranted.

Another result from the Table 5 is that RNI and RNIPD are relatively free of any effect of possible mistakes due to improper economic assumptions as far as cow ranks are concerned. Also it could be predictable in the case of changes in prices during the time it would have very little effect on correlations between RNI and RNIPD and therefore on the cow ranking.

Despite the finding of Beaudry *et al*. (1988) all correlations between measures of RNIPD were high and rounded to 0.995. Correlations between various RNI were a little bigger than correlations between various RNIPD measures. Correlation between RNI and RNIPD was high (0.79).

CONCLUSION

Simulated changes in prices caused changes in means of RNI and RNIPD. Correlations between estimates of profit in different situations, however, were quite high. This investigation showed that increase and decrease in prices can not affect the rank of cows. Thus in the studies of RNI and RNIPD, investigator should not be worried about mild alterations in prices. Examining the result of altering the unit price of different economic items showed that raising the milk price would compensate the result of increasing cost price (feed and non-feed costs) and consequently would stabilize the mean life time profit of a population. For example, in the case of increasing feed price by 1%, increasing milk price by 0.61% would leave RNI unchanged. The same result would be expected for RNIPD through increasing milk price by 0.67%. Increasing the milk price by 0.22 and 0.24% would remove the negative effect of one percent increasing non-feed cost from RNI and RNIPD, respectively.

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