ESTIMATION OF RELATIVE ECONOMIC VALUES FOR PRODUCTION AND NON-PRODUCTION TRAITS FROM FIELD DATA, USING PROFIT FUNCTIONS

by

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GRADUATE COLLEGE
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ESTIMATION OF RELATIVE ECONOMIC VALUES FOR PRODUCTION AND NON-PRODUCTION TRAITS FROM FIELD DATA, USING PROFIT FUNCTIONS.

Shylaja Jagannatha, Ph.D.

University of Nebraska, 1996

Advisor: Jeffrey F. Keown

Lifetime production records of 122,679 cows and production data of 691,383 lactations obtained from MidStates Dairy Records Processing Center, Ames, Iowa, were used to estimate relative economic values for production to herd life and production to somatic cell score.

Using lifetime production data, relative net income and relative net income for the planning horizon were calculated as income minus costs. Planning horizon of five lactations was chosen and cows culled before fifth lactation were credited with profit from replacements to obtain relative net income for the planning horizon. Income was from sale of milk, calves and cull cows. Costs were for heifer rearing, feed, labor and breeding. Profits were regressed on milk, fat and protein yields, and herd life. Regression coefficients were multiplied by unadjusted phenotypic standard deviations of traits to obtain relative economic values. Relative economic value for production to herd life was .18:1 for relative net income, and .46:1 for relative net income for planning horizon. Value of herd life was overestimated by about 2.5 times when profit from replacements was ignored. Heritability of herd life estimated using animal and sire models of .50 was used to obtain predicted transmitting abilities for herd life. As the estimated heritability was higher than most estimates from literature, predicted transmitting abilities for herd life were calculated for different values of heritability (.05, .10, .20, .50). Profits were

regressed on predicted transmitting abilities for milk, fat and protein yields, and herd life. Relative economic values obtained from regression coefficients and standard deviations of predicted transmitting abilities, were similar to relative economic values obtained when profits were regressed on phenotypic measures. For profit regressed on predicted transmitting abilities, relative economic values did not differ much with change in assumed heritability of herd life.

Relative net income per lactation was obtained for 691,383 lactations as income minus costs, to estimate relative economic value of production to somatic cell score. Income was from milk, fat and protein yields, and premium for somatic cell count. Costs were from breeding, feed and labor requirements. Relative net income per lactation was regressed on production yields and somatic cell score. Regression coefficients were multiplied by unadjusted phenotypic standard deviations of traits to obtain relative economic value for production to somatic cell score, which was 1: -.21. Large negative value for somatic cell score was mostly due to premiums paid for somatic cell count because, relative values were 1:-.015 when premiums for somatic cell count were not used in calculating income.

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INTRODUCTION

In dairy production, the major financial returns are from sale of milk, male calves, surplus female calves and cull cows. The major costs are for feed, health, reproduction and cow replacement. For efficient dairy farming, the objective should be to maximize profit and not just production. Profit could be defined as returns minus costs. One of the main tools to increase efficiency is through genetic improvement. To accomplish this, animals with highest estimated economic merit are chosen as parents for the next generation. With several production and non-production traits contributing to economic merit, economic values are used to combine estimated breeding values for component traits into an estimated breeding value for economic merit for selection purposes. Production traits include milk, fat and protein yields. Non-production traits with the greatest contribution to economic merit include health traits, reproductive traits and herd life.

Replacement costs are directly related to the herd life of cows. The length of herd life has two distinct effects on herd profitability. If a high proportion of heifers survive to maturity, then not only will fewer dairy replacements be necessary, but the average age of the herd will be greater and so more cows will be producing at mature levels. Health traits and reproductive traits such as days open and days dry are directly correlated to herd life. Improved health and reproduction prolong herd life by decreasing premature culling due to disease and/or reproductive failure. Most studies which have estimated economic value for herd life from a profit equation have not accounted for costs and income from replacement of culled cows. Such studies assume that a cow is not replaced after leaving

the herd which is not true. The first goal of the present study was to estimate economic value of herd life after accounting for income from replacements.

Relatively more importance has been given to the derivation of economic values for production traits compared to non-production traits. The option to include non-production traits along with production traits in the economic index is commonly available to dairy producers now. Optimum application requires accurate estimation of economic values for each trait in the index. However, the task of obtaining accurate economic values has not been completely resolved. Whether the economic coefficients should be obtained per unit of phenotypic change or per unit of genetic change has been a point of debate. A second objective of this study was to derive economic values for herd life per unit of genetic change and compare it with values per unit of phenotypic change.

Mastitis is one of the most costly diseases for the dairy industry. Rapid genetic improvement in milk yield is known to be accompanied by a slow increase in susceptibility to mastitis, thus increasing health costs. This susceptibility is also reflected in increased somatic cell count which is shown to be a consistent and reliable measure of udder health. Correlations between mastitis and somatic cell count are moderately high and estimates of heritability for somatic cell count in the literature range from .05 to .29. Moreover, somatic cell count at subclinical infection levels may reflect decreased quality of fluid milk and decreased general well being of a dairy cow. Therefore, indirect selection for mastitis resistance through somatic cell count may be an efficient way to decrease the rate of clinical infections. However, an overemphasis on genetic evaluations for somatic cell count could undermine the established importance of selecting for increased

production. The third objective of the present study was to determine the economic value of somatic cell score, which is a log linear transformation of somatic cell count, relative to production.

LITERATURE REVIEW

Methodology for derivation of economic values

Hazel (1943) stated that "the relative economic value depends upon the amount by which profit may be expected to increase for each unit of improvement in that trait". Therefore, the definition of a profit function has been the first step in determining the economic value of a number of traits. Since the original work of Hazel (1943), several researchers have used different methodologies for developing profit functions and economic values. Harris and Newman (1994) state that the basic economic values involved in the development of profit functions for any class of livestock include:

1. Cost of feed per unit weight
2. Cost of labor and facilities per unit of time
3. Value per unit weight for products
4. Cost of initial animals

Pearson and Miller (1981) note that variation in the numerous studies with profit functions is mainly in method of estimation and completeness of items and also indicate that estimates of income and expenses should be as complete as possible. Bright (1991) compared methods employed by animal breeders and economists to estimate economic weights. He concluded that the 'simple' profit function would be sufficiently accurate in most circumstances. Profit defined as returns minus costs can be compared to economic efficiency which is returns divided by costs as proposed by Dickerson (1970). More recently Smith et al. (1986) argued for the use of economic efficiency objectives. Keller and Allaire (1990) showed that using returns minus costs inflates economic weights

compared to using returns divided by costs. However, they found relative economic values to be similar for profit and economic efficiency. Balaine et al. (1981) concluded that profit expressed as a linear function of income minus expenses for a given period of herd life is best. Pearson and Miller (1981) state that such a linear function is easily understood and also easy to work with. Weller (1994) concluded that economic efficiency is advantageous for comparing different species and production systems. The advantage is of no consequence in the present study as only Holstein cows from mid-section of United States are considered. Harris (1970) explained that the animal breeder's primary unit of selection is usually the individual animal and therefore an individual animal's contribution to income and expenses is necessary to obtain economic weights for different traits. Weller (1994) stated that profit per animal is justifiable only under a very short profit horizon as the dairy farmer can increase number of cows over a space of several months or year. Profit per animal calculated for animals from a large population from several herds may tend to overcome this problem. Therefore, a profit function can be used to determine the profitability of an individual animal or of an individual animal on a per unit time basis. Norman and Dickerson (1971) stated that either profit per animal or profit per animal per unit of time can be used with a selection index approach to derive economic weights.

Definition of production system in terms of different levels of the farm system have been based: on a per animal basis(de Jager and Kennedy, 1987; Bekman and Van Arendonk, 1993), on a per farm basis (Groen 1989a,b; Keller and Allaire, 1990) and on a macro economic basis (Moav, 1973). Brascamp et al. (1985) used the concept of normal profit to show that economic weights derived from a profit function describing different

economic perspectives such as per female, per individual and per unit of product were equivalent. Long term profit for all producers is zero because the operating profit is considered a cost of production. Some studies have based calculations on a per animal basis considering a large population from more than one herd (e.g., Gill and Allaire, 1976a,b; Tigges et al.,1986). Deriving economic weights using a model of farm production and economics is more important for pasture based dairy production where there are restrictions such as stocking rate or feed resources. Gibson (1989a) discussed methods for deriving economic weights for milk components using the Canadian milk market as an example. The procedure suggested was developed for situations in which output restrictions exist in the milk market and incorporated the concepts of rescaling discussed by Smith et al. (1986). Gibson (1989b) noted that, in a market where there are no output restrictions, rescaling is not required. However, the economic weights were found to vary widely, depending on whether a restricted or a free market was assumed. The present study includes data from a large population of cows from several herds in the midwest where there are no output restrictions.

Methods for deriving economic weights can be divided into positive (data analysis) (Tigges et al.,1984; Van Arendonk,1991; Weigel et al., 1995a) and normative (bioeconomic modeling) (Harris and Freeman, 1993; Van Arendonk et al., 1985b; Gibson,1989b). With a positive approach, economic weights are calculated from data realized under the given production circumstances. The positive approach cannot account for the influence of changes in optimum management with changes in genetic level and also does not offer the opportunity to study the influence of changes in the production

level or of prices on the economic weights. The normative approach can solve the latter problem. Groen and Ruyter (1990) in a literature review on the derivation of economic values of milk production traits, concluded that positive analysis is theoretically less suitable because the analysis is of the 'past' rather than prediction of 'future' as should be done in calculating benefits of breeding decisions. However, Van Arendonk (1991) explained that knowledge of traits and their relationships is needed for accurate modeling of economic merit of profit. For secondary or non-production traits such as herd life, these relationships are not adequately known. For such traits a positive approach can prove to be useful.

Herd life

Herd life or longevity has been expressed as a number of different traits: number of lactations , age at disposal (Hoque and Hodges, 1980), stayability (Everett et al.,1976a,b; Hudson and Van Vleck, 1981) and survival scores (Madgwick and Goddard, 1989). The economic importance of herd life has also been well documented (Gill and Allaire, 1976a; Allaire and Cunningham, 1976; Bakker et al., 1980; Balaine at al., 1981; Congleton and King, 1984; Van Arendonk, 1985a; and Allaire and Keller, 1990). The economics of increased herd life come from two distinct effects on herd profitability. Replacement costs are reduced and income is increased as a result of a higher proportion of cows producing at mature levels. Cows with longer herd life survive culling due to infertility, health reasons and low production. As a result, herd life could be associated with improved health (lower veterinary costs and less production loss).

Heritability of herd life depends on definition of the trait. Visscher et al. (1994) showed that when herd life is expressed as a continuous trait (e.g., total length of herd life, productive life, age at last calving) heritability is considerably higher than when herd life is expressed as a categorical trait (e.g., number of lactations, survival to a certain age). Most estimates of heritability of herd life expressed as a continuous trait range from .03 to .10 (e.g., Ducrocq et al., 1988; Boldman et al., 1992; VanRaden and Klaaskate, 1993). However, Gill and Allaire (1976b) found a larger estimate of .25$\pm$.09. Heritability estimates for herd life expressed as a categorical trait have been generally less than .05 (e.g., Van Doormal et al., 1985; Dentine et al., 1987; Brotherstone and Hill, 1991; Visscher et al., 1994). Estimates of genetic correlations among stayability measures at consecutive ages are generally greater than .80 (Dentine et al., 1987; Rogers et al., 1990; Short and Lawlor, 1992; Van Doormal et al., 1994). Estimates of genetic correlation between herd life and production range from .30 to .90 (Short and Lawlor, 1992; VanRaden and Klaaskate, 1993; Visscher et al.,1994). However, when herd life is adjusted for milk production (functional herd life), the correlation is close to zero (Ducrocq et al.,1988; Short and Lawlor, 1992). Dekkers and Jairath (1994) state that these theoretical estimates should be interpreted with care as they could be upwardly biased due to voluntary culling based on low production. However, herd life is more highly correlated with cow profit than any other trait except production (Gill and Allaire, 1976a; Allaire and Keller, 1990) and therefore, should be considered as an important trait to be included in the breeding objective in addition to milk production.

The economic value for herd life has been estimated by several authors. Type scores have been used as indirect predictors of herd life (Boldman et al., 1992 and Veerkamp et al., 1995). Harris and Freeman (1993) and Veerkamp et al. (1995) derived economic value for herd life predicted from type scores. Harris and Freeman (1993) used linear programming to estimate economic values of three type traits, stature, body depth and udder depth, used as predictors of herd life. The relative economic value of production to herd life was approximately 8:1. Veerkamp et al. (1995) chose angularity, foot angle, udder depth and teat length to predict herd life. Expressed in units of genetic standard deviations, the weights for protein, fat, milk and longevity (relative to protein) were 1, 0.21, -0.25 and 0.55 respectively. Several other authors estimated relative economic values of a direct measure of herd life using profit equations or functions (Andrus and McGilliard, 1975; Gill and Allaire, 1976; Balaine et al., 1981; Van Arendonk ,1991; Allaire and Gibson, 1992). Allaire and Gibson (1992) estimated the relative economic weight per genetic standard deviation of milk to herd life adjusted for milk production to be 3.2:1. Van Arendonk (1991) proposed that profit functions should be adjusted for the opportunity cost of postponed replacement. He argued that when opportunity costs are not accounted for, the value of herd life is determined by the net revenues during each additional day . Ignoring opportunity costs also implies that the number of cows in the herd is considered to vary with the length of herd life, which is not true. Van Arendonk (1991) found the relative value of herd life to be overestimated by 260% when opportunity costs of postponed replacement was ignored. Opportunity cost was defined as the profit sacrificed on an average replacement cow by keeping the cow.

More recently, other studies have considered the application of opportunity cost to relative net income (de Haan et al., 1992 ; Cassell et al., 1993; Weigel et al., 1995b). Van Arendonk (1991) used the same opportunity costs for all cows, whereas de Haan et. al. (1992) modified that by using specific opportunity costs for each herd year of freshening. The results were consistent with the prediction of Van Arendonk (1991) that adjustment for opportunity cost reduces impact of length of productive life. All studies which considered opportunity costs assumed that the replacement cow would offer the same potential for profit as an average cow with the same herd life as the culled cow. However, herd life of the replacement may not be the same as that of the culled cow. Dynamic programming (Rogers et al., 1988; Van Arendonk, 1985b; Van Arendonk and Dijkhuizen, 1985; Veerkamp et al., 1995) is one of the modeling methods that has been used to determine the relative value of production and herd life in dairy cattle. This technique is based on replacement principles. However, the study by Van Arendonk (1991) was the first to incorporate opportunity cost into a profit equation to estimate relative economic value for herd life using field data. Genetic improvement was not simulated for a replacement taking the place of a culled cow. The present study attempts to estimate the relative economic value of herd life from field data using a profit function after accounting for income from replacements. Improvement in genetic trend for production is incorporated into estimated production from average replacements. This is not considered in the study by Van Arendonk (1991). In the present study, a profit horizon is chosen and the number of replacements necessary to replace a culled cow within the profit horizon is calculated using probabilities of survival.

Planning Horizon

Groen and Ruyter (1990) in a review of derivation of economic weights for milk components found that only a few references made a concrete choice of the planning term. Some studies have considered lifetime records of cows without choosing a particular planning horizon (Gill and Allaire, 1976; Norman et al., 1981). Balaine et al. (1981) considered up to three lactations to calculate profit functions and Visscher and Goddard (1995) considered up to ten lactations per cow. Weigel et al. (1995b) considered an opportunity for herd life up to 84 months. Harris and Freeman (1993) estimated economic weights based on optimum response to selection for four different planning horizons. They analyzed 5, 10, 15 and 20-year planning horizons and concluded that the economic consequences of response to selection to the entire producer production system over a given planning horizon can be taken into account. Miller and Pearson (1979) explain that the planning horizon for animal breeding should be medium to long term in order to reap full benefits of breeding decisions. Therefore, the derivation of economic weights should take into account long term structure of the market and not just immediate circumstances, regardless of whether economic weights are estimated based on response to selection or obtained from a multiple regression analysis of economic merit/profit on different traits. McMahon et al. (1985) concluded that a two generation planning horizon was sufficiently long, as sires ranked nearly the same with longer horizons. In the present study a profit horizon of five lactations is considered for each cow.

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