The Marginal Cow I

The world for the most part uses economics that dictate that for a business income is maximized at the point where marginal cost (MC) equals marginal revenue (MR). The logic behind this is simple: for a given business system (firm or farm) production is increased until the next unit of output will return less than the additional cost of the inputs i.e. increasing production further loses money.

World pastoral agriculture including NZ still does not apply marginal cost/revenue thinking - despite it being fundamental to competing industries such as chicken or pig production.

If pastoral agricultural producers were using marginal thinking (cost and/or revenue) then dairy farmers would for example be aware that the production functions for their farm systems are of the nature of the following graph.

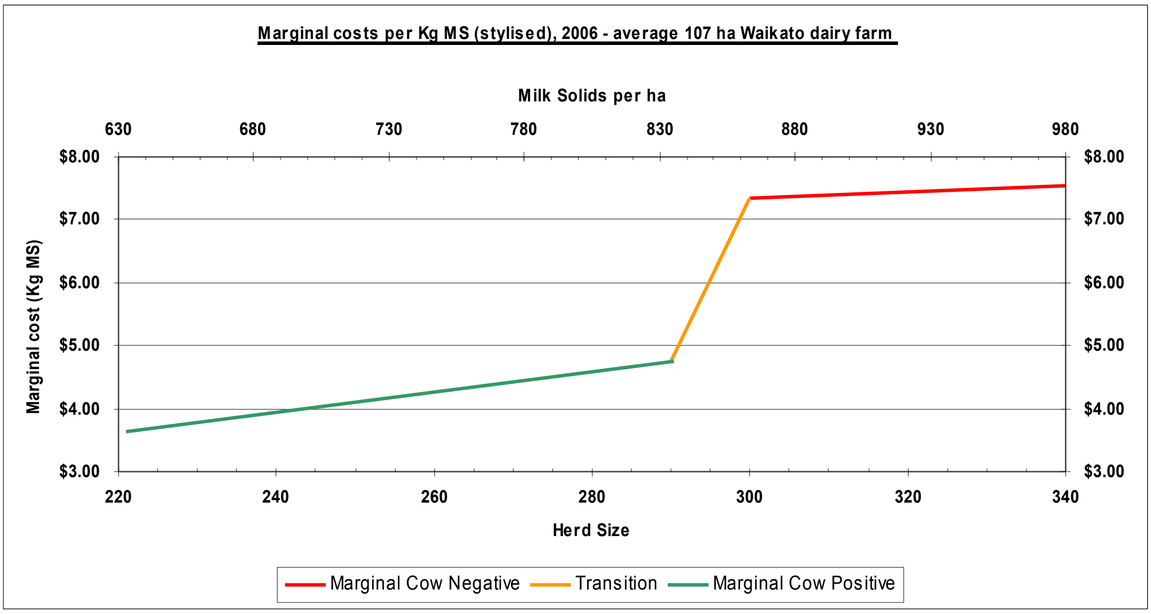

Figure 1

Whether areas of the curve are marginal cow positive or negative does depend on the milk solids (MS) payout, but the descriptions used here certainly apply to payouts between $5.00 and $7.00.

The average NZ dairy farm is now operating beyond the point where additional production returns less than the cost of that production. The herd size for the average dairy farm in the Waikato is in excess of 300 cows and producing at just under 900Kg MS per ha. From the above graph it is clearly operating marginal cow negative.

Pastoral agriculture in NZ has not embraced the MC=MR economic approach to setting production levels for two largely historical reasons. The first of these is that until sometime during the 1990's - and still is in many lower cost production countries of the world – it was simply not necessary to know. Increasing production from a farm system using good farming practice nearly always increased income. This is now largely a historical reason because dairy farms are operating with marginal costs high enough that they can easily exceed marginal revenue, and often do in many of the more intensive farm systems.

The second reason is that pastoral production systems require matching dry matter production with animal production and this is a complex art (it is actually more science than art). Accurately determining the marginal income response to inputs was difficult - mangers were left relying on one or more component based margins or using averaged costs and responses.

Bio-economic models now more than adequately handle optimising resource allocation decisions and prescribe the production settings where profit is maximal – effectively the point where MC=MR. This excuse for not knowing where MC=MR no longer applies.

A third reason, still current, promoted by the agri-business community is that NZ agriculture is no longer primarily about making taxable profit but a property management business focused on asset appreciation.

Presuming taxable income is still important, what is the cost of not knowing the profit maximizing level of production to NZ and NZ farmers? Producing beyond MC=MR means the use of additional resources leads to a decrease in income. This is not smart and irresponsible on a number of counts – economically, environmentally and in terms of sustainability. If the difference between producing MC < MR and MC > MR is in the order of several hundred dollars per cow then every dairy farmer is surely obliged to know whether they are operating marginal cow positive or marginal cow negative.

The hard way to introduce the concepts of MC=MR to dairy farm production, and one almost guaranteed to make eyes glaze over, is to break marginality in to its components e.g. Nitrogen response, supplement use, genetics, etc. and look at the partial impact of each on milk solids production and profit. This approach never succeeds because it is impossible to reconcile the effects of competing components especially as their impacts change approaching an optimum resource allocation mix.

The pragmatic way is to use an example that should be familiar. Let a bio-economic model optimise resource use for a model farm, but also force the model to simulate this for a range of herd sizes ranging from clear under production through to clear over production - effectively to plot the marginal value (change in income) of adding each cow to the herd one by one.

The farm used in this simulation is an average 107 ha Waikato dairy farm producing 12,150 Kg of dry matter (DM) averaging 11 Mega Joules of metabolisable energy (MJME) and using 500 Kg liveweight, 350 Kg MS cows. Per cow costs excluding feed are $790. MS payout is $5.50/Kg MS. The farm has infrastructure to allow 400 cows to be milked and the feeding of up to 40% of the required DM as supplements.

The results from this exercise may come as a surprise to those used to working with average rather than marginal costs and revenue. The red marginal effective farm surplus (MEFS) per cow line of Figure 2 shows the value of each additional cow dropping from positive $340 at a herd size of 288 cows to negative $448 at a herd size of 300 cows – a decrease of $750 over an increase of only 12 cows.

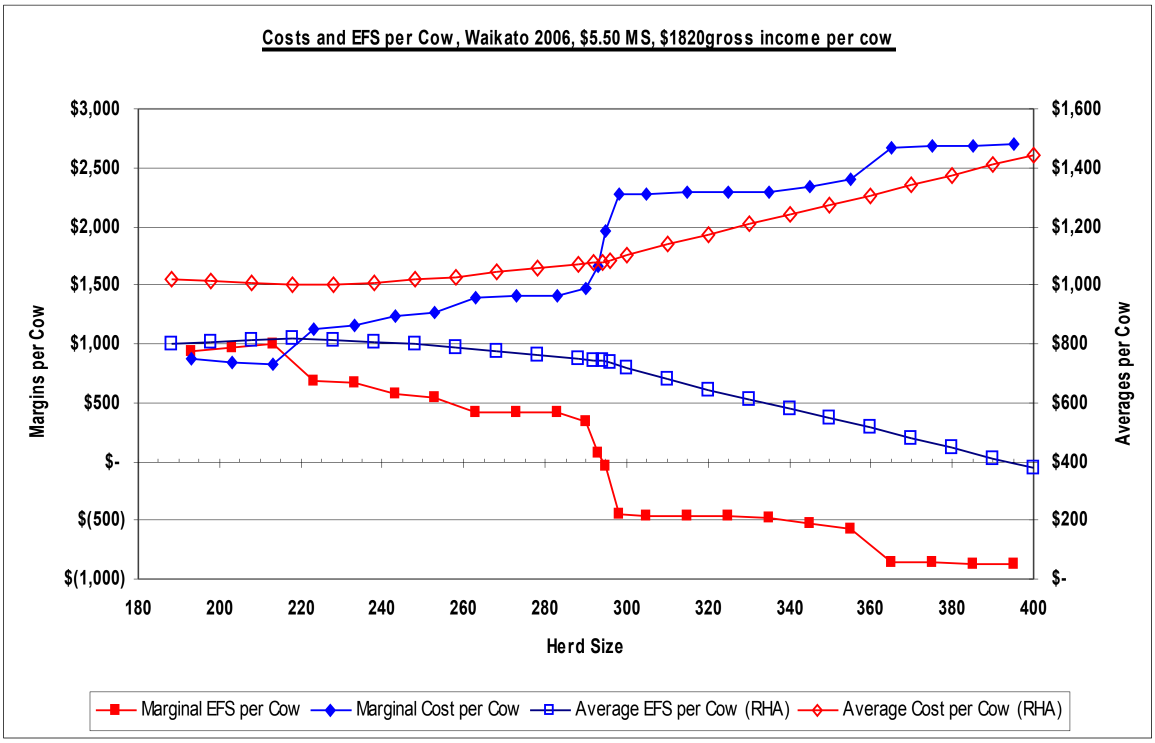

Figure 2

If we look at the blue average effective farm surplus (EFS) line it appears that shifting from a herd size of 294 cows to 300 has added 6 cows at an average EFS of $720. The average EFS per cow only drops from $740 to $720. That $20 shift is small enough to get lost in the noise. Those 6 cows appear to have added 6 times $720 ($4,320) but have also reduced the EFS per cow of the first 294 cows by $20 ($5880). Not a smart move, and one showing the tyranny of using averages rather than marginal thinking.

Adding 6 cows to the herd of 294 adds 1897 Kg MS to production, but costs $1,560 in income. If the purpose of this farm is profit maximization then this increase in production is counter productive. If the purpose of the farm is alternatively asset appreciation, then that extra 1900 Kg of MS production may have added $95,000 to some estimates of the farm value. Same farm, less taxable profit but great asset appreciation.

It is not normal practice in farm management to have a production curve giving average per cow EFS for the farm over a range of herd sizes. We have these because we have been taking a marginal approach to maximising profit and setting production levels - simulating possible future outcomes rather than retrospectively analysing past performance.

When you do take this approach a range of information can be presented. An interesting graph is the influence of dry matter costs and purchased supplements on marginal returns as in Figure 3.

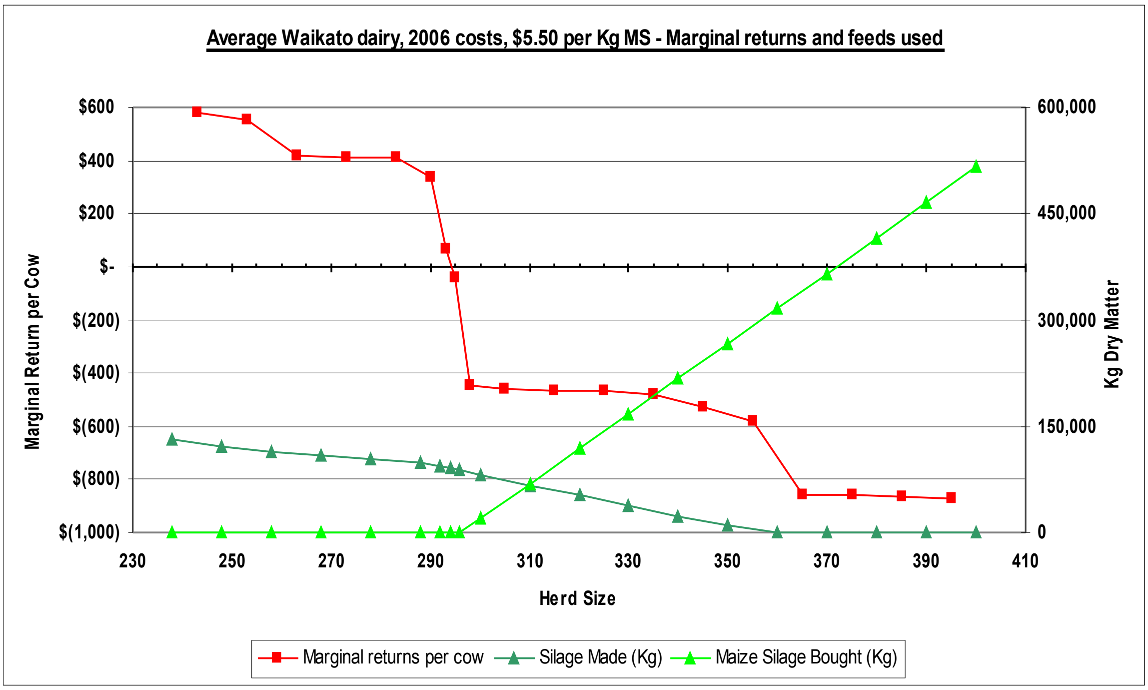

Figure 3

Figure 4 shows the marginal costs for milk solids production and which are independent of payout. MS payout is a reasonable proxy for dairy farm marginal revenue. Using this information it is easy to determine the production level for maximum profit (where MC=MR) at any anticipated payout.

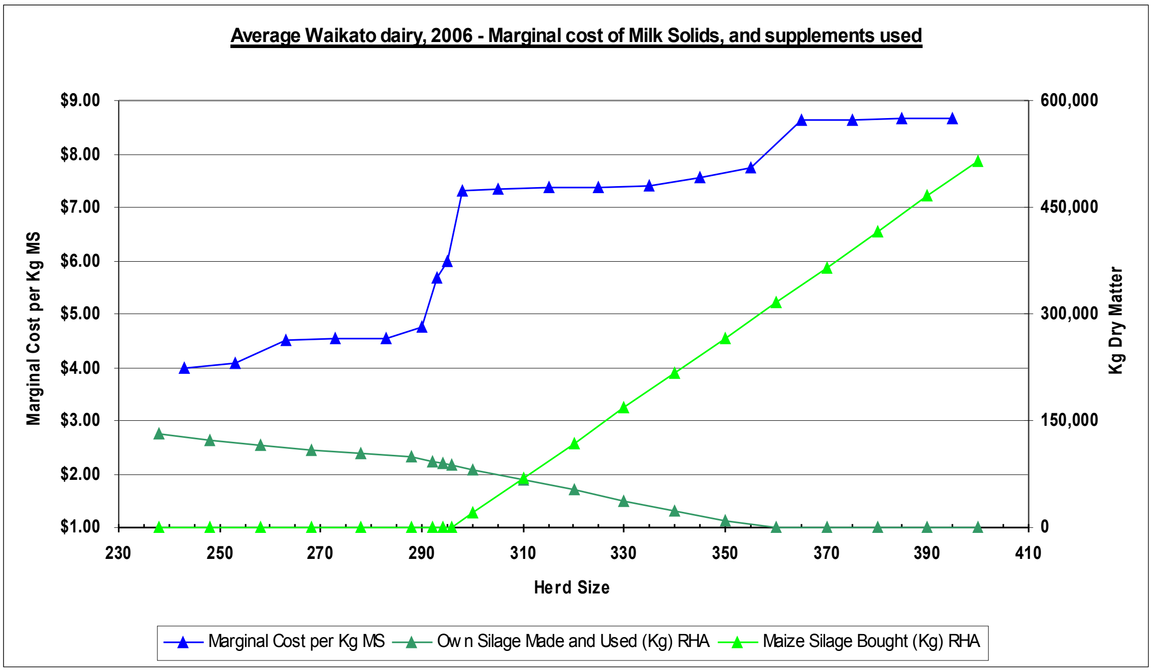

Figure 4

A farm though typically only has a single set of financial indicators from the last production season on which to base decisions on current and future production. Figure 5 shows three such indicators from four farm systems. Such use of an average cost/revenue approach provides little guidance as to which of these farm systems should increase or decrease production.

It is not apparent from the data, but one of these farms is marginal cow positive (should increase herd size), two farms are marginal cow negative (should decrease production) and one farm is close to the optimal level of production.

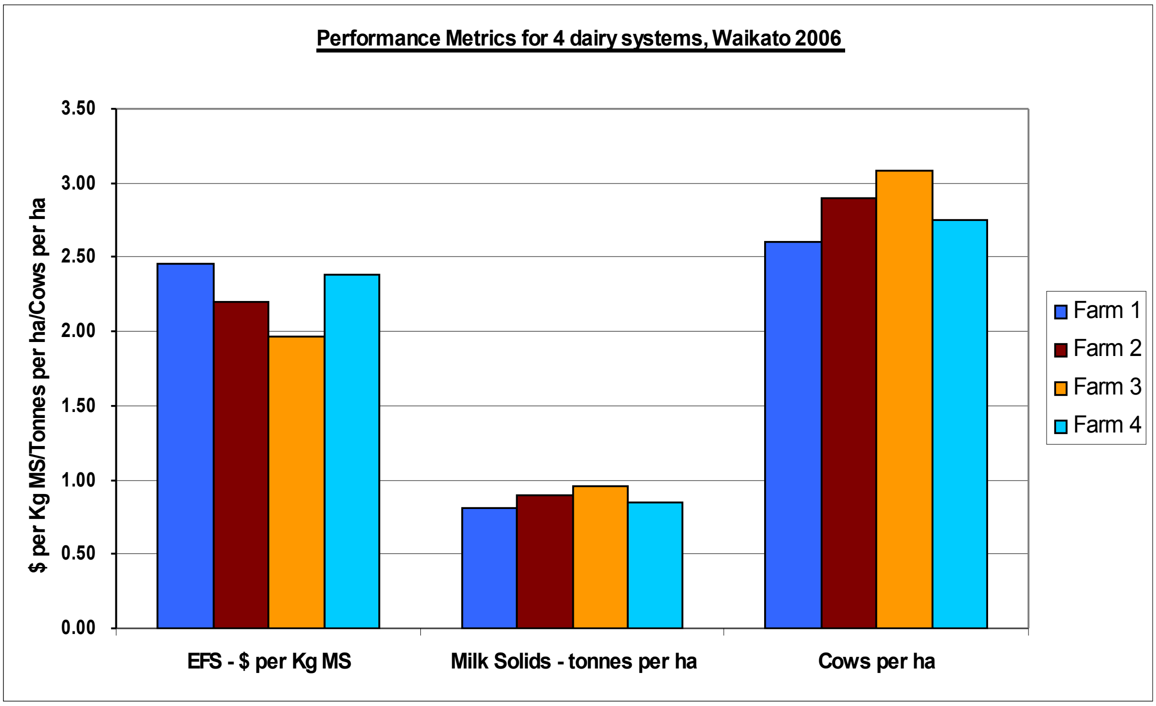

Figure 5

Farms 1 to 4 are actually the same farm that has been used throughout this article but operating at herd sizes of 278, 310, 330 and 294 cows. Farm 4 is the most profitable and farm 3 the least profitable.

Farm 1 has the smallest herd size (278) and could increase herd size 16 cows to achieve maximum profit. Farms 2 (310 cows) and 3 (330 cows) should decrease herd size by 16 and 36 cows respectively to achieve the same.

Three issues arise from this: Concepts around operating at MC=MR are not well understood in pastoral agriculture; Even if marginal costs and revenue are understood, current management approaches don't identify the profit maximizing production points and; The application of MC=MR concepts to farming is in conflict with maximizing agricultural asset values based on current methods of valuation.

Marginal cost curves provide information of great value. They are not hard to establish using bio-economic models. Such models would normally also optimise resource use.

Each farm will have a different production function, and these will vary each year as costs and environment change. The nature of the pastoral production function and increasing marginal costs are though fundamental for dairy farms.

Similar concepts apply equally to pastoral systems producing sheep, beef or deer.