

Material about farm management from A/Prof Bill Malcolm for Dairy Providers Meeting Tuesday 7th of August of 2012

Group Purpose

“A collective group of rural professionals working together to enhance the service delivered to dairy farmers in Tasmania”

Programme

Location: Edge Water; 4 Thomas St, Devonport 1st Floor

Theme: “Enhancing collaboration within the rural professionals (RP) group”

Objectives

- Understand what TIA (Tasmania Institute of Agriculture) is and what it does
- Provide a forum for rural professionals (RPs) to introduce themselves and discuss options for better collaboration
- Build business management capability within the group (Professor Bill Malcolm, University of Melbourne)

PAPER NO.1

Thinking about

- (i) evaluating how a farm business is performing and
- (ii) evaluating the likely net gains from making a change to a farm system

Introduction

Assessing how well or poorly a dairy business is performing or will perform must be in the context of the goals of the owners and all the resources of their farm system with which they have to work and the risks involved.

The first question to ask is why am I investigating farm performance?

There are three reasons:

1. To understand how the farm system works (**What Is**)
2. To work out how to best change the way the farm system works (**What Could Be**)
3. That is, **to work out what to do and how to do it**

Understanding the Big Picture (Beyond the Farm)

The detail of the future that will happen is unknowable. Many of the elements of it are knowable – the fundamentals- though their magnitudes cannot be known. So don't bother. Cycles happen. Things are either getting better or getting worse. The ride is always rough. Prepare for it, don't predict it.

So:

Run your business so that, given reasonable expectations about medium term prices and with full awareness that anything from too wet to dry can happen on the weather front, your business has a reasonable probability of earning a rate of return on capital that is satisfactory to you; has a good chance of servicing existing debt and new debt that may arise from unexpected additional debt arising from bad business conditions or new debt that will be taken on to grow the business and remain competitive; and will have a good chance that the business will enable you to meet your goals including increasing your wealth.

Understanding the Little Picture (Within the Farm)

This is where we can do something about our dairy-farming fate; a fate that is determined by:

- How passionate you are about your business
- How well you understand the technical, economic, financial and risk elements of your business and how these elements join forces to create profit, or loss
- You, the entrepreneur, identifying what it is that you and your capital are relatively better at doing than are your competitors, and, in the spirit of continual improvement, taking on the challenge of doing it better.

- (a) **Some things pretty much everyone involved with farm business (farmers, bankers, accountants, consultants, agribusiness input suppliers) think they 'know', but usually don't; and**

(b) Things we'd all be better off if everyone involved with farm business did know more about

(a) Things people think they know. But often don't....

The right numbers:

The whole farm approach, what profit is, what return on capital is, what debt servicing capacity is, what is a sound and unsound balance sheet, how much to pay for durable, non-depreciable, appreciating assets, how much to pay for depreciable, reproducible assets, what is good information or bad information, using the right numbers.

The right numbers are numbers about your business that are relevant to managing your business. The right numbers are not numbers done by the accountant for tax purposes, nor numbers that ignore hundreds of years of economic theory; categories of numbers that are instead blissfully and audaciously invented by consultants. For example, accountants calculate net profit, and do not separate annual costs into fixed and variable costs. Management economists distinguish between the costs you have no discretion or control over in the production year/planning period in which decisions are being made about inputs to make outputs - called fixed costs - and costs the manager is managing in that period - called variable costs. The idea is to use variable costs as well as can be to generate income to cover fixed costs and leave a profit. The made up concept - core costs - have never been part of the economic text books.

Using the right numbers about how the business might perform in the planning period, or, sometimes, how it has performed in the year just past, means applying the trifecta approach to the numbers. Evaluate profit (efficiency), cash (liquidity) and growth (wealth) and weigh up the overall performance of the business in terms of how the business has done or will do *according to each of these measures*.

This entails:

- Starting with the balance sheet, not the farm activity, for the planning and analysis period in question
- Assessing annual farm performance in terms of three criteria efficiency (profit), liquidity (cash flows) and wealth or growth (change in equity)
- Applying risk analysis techniques to annual debt servicing ability, liquidity and growth prospects as well as the question of expected efficiency/expected return on capital.
- An approach is to this end set out below:

(i) Balance Sheet at Start of relevant planning period:

Total Assets Controlled (including leased assets if any), Total Debt (including present value of future lease payments if leased assets), and Equity

(ii) Annual Whole Farm Profit and Growth Budget

Expected Gross Income

Minus Activity Variable Costs

Equals Expected Whole Farm Gross Margin

Minus Cash and Non-Cash Overhead Costs (including depreciation, operator allowance for labour and management)

Equals Expected Operating Profit (Efficiency when expressed as Return on Total Capital)

Minus Interest and Lease Costs

Equals Expected Net Profit (Return to Owners Equity)

Minus Estimated Income Tax

Equals Net Profit after tax

Minus any Consumption/Drawings from cash flow above operator allowance already deducted (if owner operator), or Add Back any part of operator allowance deducted as overhead cost but not actually consumed/withdrawn from cash flow.

Equals Growth (change in wealth)

This formulation tells about Efficiency and Growth, and incorporates the critically important links between efficiency and gearing and growth. Liquidity must also be included in any farm management analysis. This requires the expected cash flow budget.

(iii) Expected sources of cash for the coming year/planning period

Expected sources of cash for the coming year/planning period

Minus Expected uses of cash before debt servicing obligations

Equals annual Net Cash Flow before interest and principal

Minus interest

Minus Principal

Equals annual Net Cash Flow after debt servicing

Having quantified efficiency, growth and liquidity aspects of the farm management analysis in question, a check is given by the end of period balance sheet (iv below) in which change in equity calculated as equity end minus equity at start will reconcile with growth as estimated in the profit and growth budget (ii).

(iv) Expected Balance Sheet at End of year/planning period.

As in(i) but with changes in debt from repayments, changes in asset values from depreciation, and changes in assets or debt arising from positive or negative expected NCF after debt servicing.

Total capital at start.

Equity	Debt
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Total Income	Variable Costs					
	Total Gross Margin	Fixed Cost				
			Operating Profit	Interest		
			Net Profit		Tax	
					Growth	

Total capital at end.

Equity	Debt	+	Growth
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Total cash in	Cash out before principal and interest		
	Cash flow before principal and interest	Principal and interest	

The overall effect of the calculations outlined above is to provide information about the performance of the business that is likely for the relevant planning period in terms of measures that comprise important components of the goals of the farm family – which are more than solely economic efficiency. Liquidity and growth in equity (net worth) are, commonly, at least as important and usually more important goals than economic efficiency; recognizing though that economic efficiency is a significant part of the way liquidity and growth goals can be pursued and met.

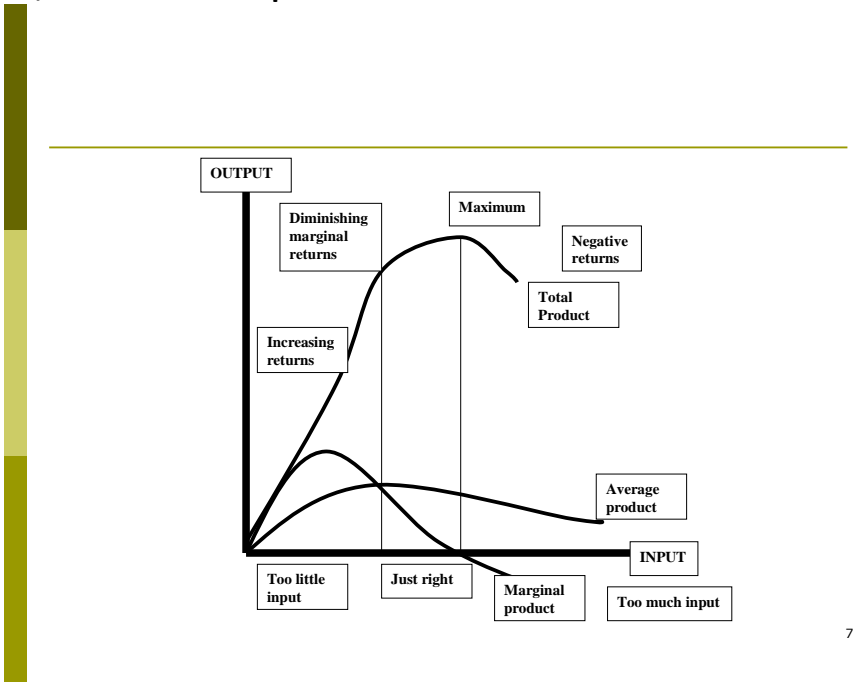
Assessing potential financial health, from changes to farm plans is as important as assessing whether a potential change to farm plan is a good investment in terms of economic efficiency (profit, return on capital). Financial health derives from both income and debt situations. The ratio of debt to total assets, the term of the debt and the interest rate on debt partly determine the extent to which debt is contributing to financial health – the rest of the story is in income, cash and assets. Investments need to be both profitable and cash flows need to be available to service debt. The point is that assessing the performance, health and stress/vulnerability of farm businesses requires a whole farm, multi-dimensional perspective. Just as partial ‘benchmarks’ of activity performance are inadequate, partial measures of business performance too are inconclusive. Farmers and people with an understanding of farm economics think, looking forward, ‘at the margin’; think about ‘response of extra output to extra input’: a bit more of this, a bit less of that, what is the effect on the whole? What are the extra benefits and costs? What are the risks? Others, non-economists, seem to look backward, thinking in terms of ‘the average physical output that came from each of the units of input used’, presuming somehow that past partial technical ratios are good indicators of future profit.

In working out what to do and how to do it, farmers need information. Often the information made available is information about other peoples farms – but how much can a farmer learn about running his own farm by looking closely at another farmers farm?

Other peoples farms can be a source of great ideas, but that’s about all: comparing the way one farm performs against a different outfit, as is done in what is commonly called ‘**Benchmarking**’ or ‘**Comparative Analysis**’ is mostly an exercise in futility. The reasons are explained below.

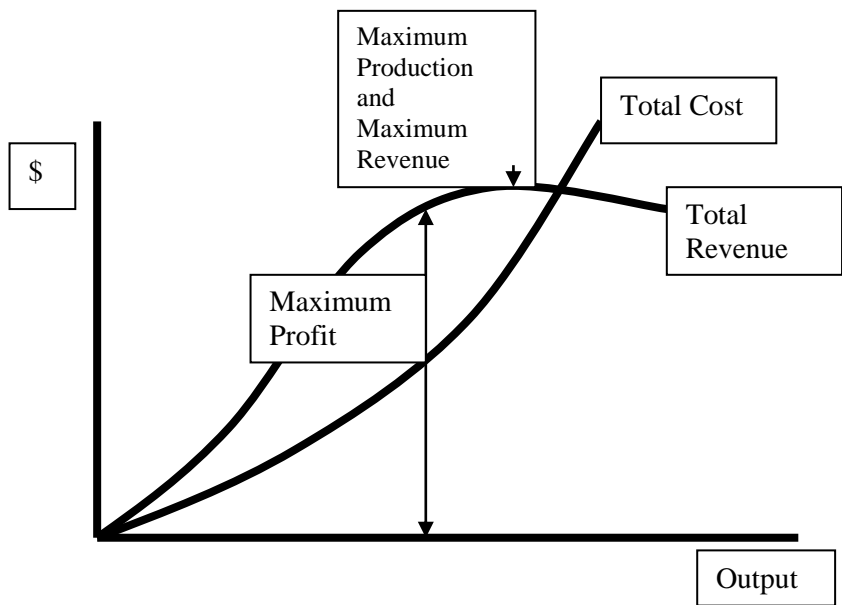
(b) Things we'd all be better off if everyone involved with farm business did know more about....that is, common mistakes people make

Mistake #1 Maximizing total production from an input, or average production from an input, makes the most profit doesn't it? No it doesn't!



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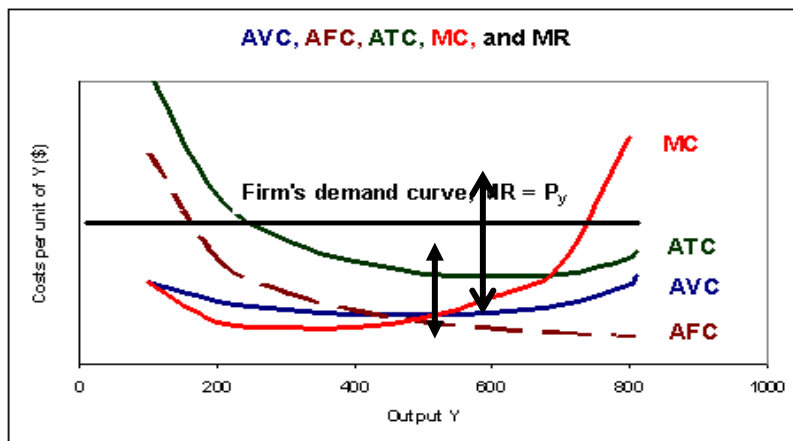
Mistake #2 Maximizing average technical efficiency ratios such as milk solids/cow or milk solids/hectare tells us how to make most profit from the system, doesn't it? No it doesn't.



Getting the technical side of things right is critical to making profit, but maximizing average technical input-output ratios does not maximize profit. In fact, these criteria

can give logically opposite advice: to maximize average production per cow would suggest running less cows. Alternatively, maximizing average production per hectare would suggest running more cows. Logically opposite conclusions! Maximizing profit requires thinking not in terms of averages of the whole system but in terms of marginal changes to the system: a bit more of this, a bit less of that. What will an extra cow add to costs and to revenue; if extra revenue exceeds extra cost, this adds to total profit.

Mistake #3 Maximizing margin over average cost makes the most profit, doesn't it? No it doesn't!



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Maximum profit level of output is just up to where the extra revenue (marginal revenue, MR) equals extra cost of making the extra output (marginal cost, MC).

ATC is average total cost

AVC is average variable costs

AFC is average fixed cost

Maximizing margin over average feed cost will not maximize profit. Feeding to where, theoretically, the cost of the last unit of feed just equals the value of the extra milk solids produced maximizes profit. This profit maximizing level of feed use is defined as where the Feed Conversion Efficiency (FCE) of the last kg of feed equals the ratio of feed cost to milk price, i.e. marginal FCE= (cost of feed/kg/value of MS/kg)

Mistake #4 Average cost of production is a meaningful number. No it isn't.

It is marginal cost not average cost that matters to profit maximizing decisions. Average cost of production of an individual business has nothing to do with price received (except for, over time, the way cost of production will affect supply of a product).

Annual average cost of production is made up of fixed (unavoidable) and variable (discretionary) costs for a year – different costs are relevant for shorter periods within a year, e.g. only annual variable costs or only some variable costs for a shorter period, e.g. for a day, only cost of feed vs value of milk produced matters.

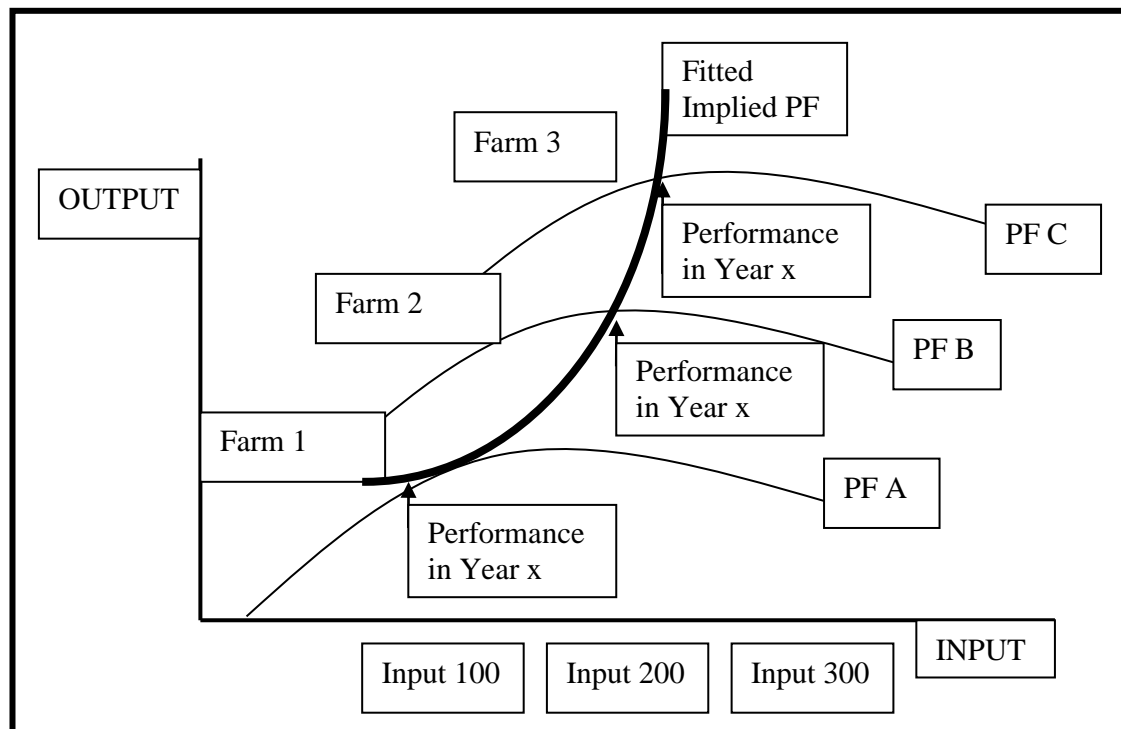
Estimates of average cost of production have arbitrary allocations of whole farm fixed costs to activities where more than one activity exists (is the fence there to keep the animals out of the crop or the crop out of the animals?). What about the case of supplementary and complementary activities – an activity might have high average cost but without it farm profit is less.

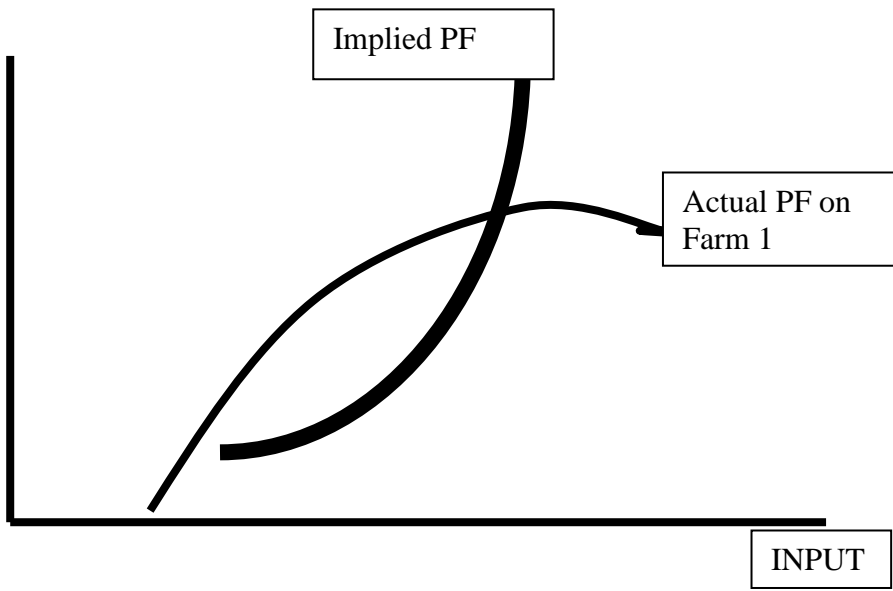
Average cost could be high because too little *or* too much output is being produced.

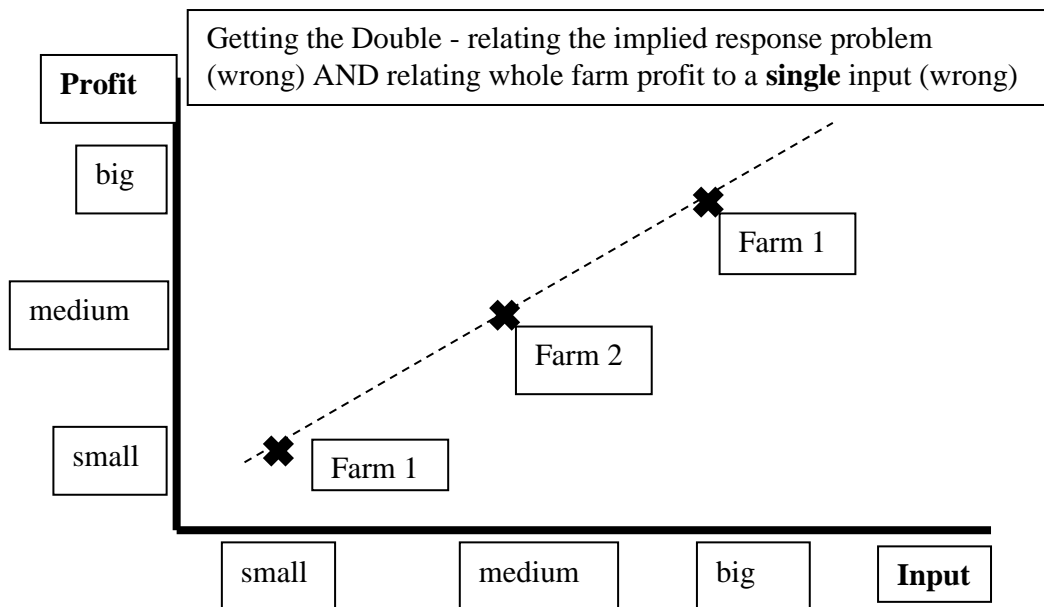
Interest cost of debt is often included as a cost of production – interest on debt is a return to suppliers of capital to the business. As well, the size, and nature, of debt is different for every business.

Mistake # 5 If *this* farm can do this then *that other* farm can do it too

5.1 The implied response function problem







- (i) Each farm has different input response functions, and operate at different points on these functions, and
- (ii) Profit is a consequence of the combination of the response functions of all the farm inputs and how they are combined.

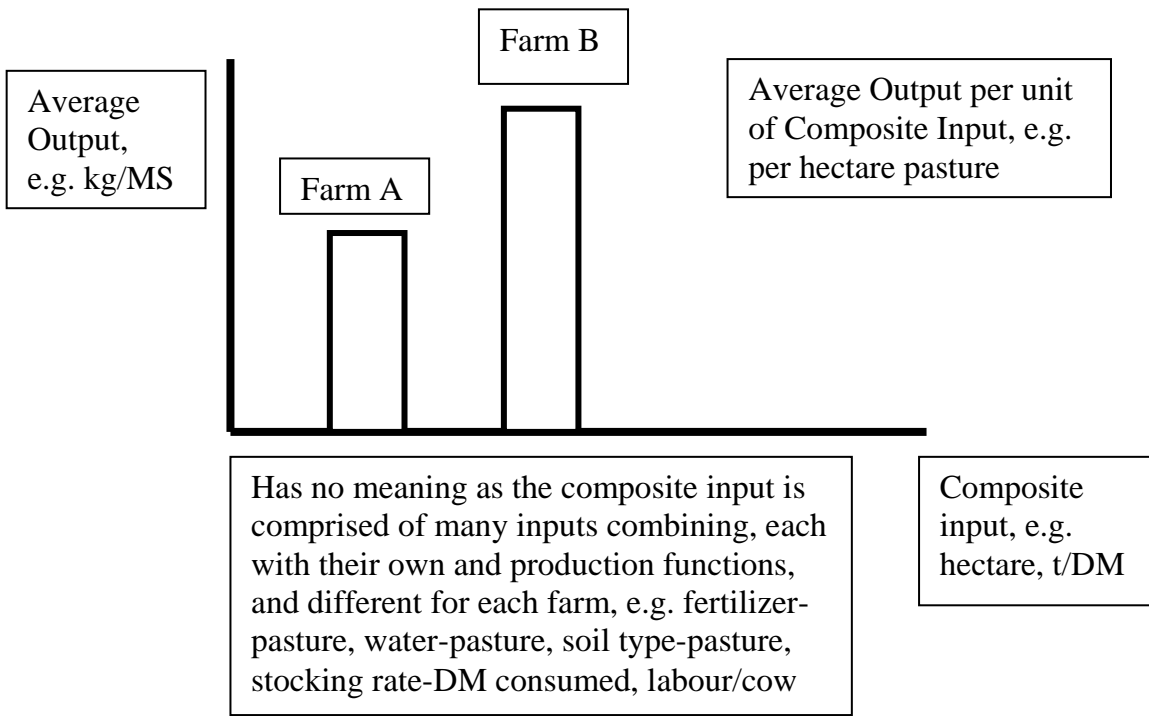
Note that profit is the residual return to all capital (land, plant, livestock) after all other inputs have been paid at their market rates.

Profit per hectare (land input) or per cow (animal input) makes as much (or as little) sense as profit per strainer post (fence input). Profit per whole system (produced by all inputs combining) makes sense.

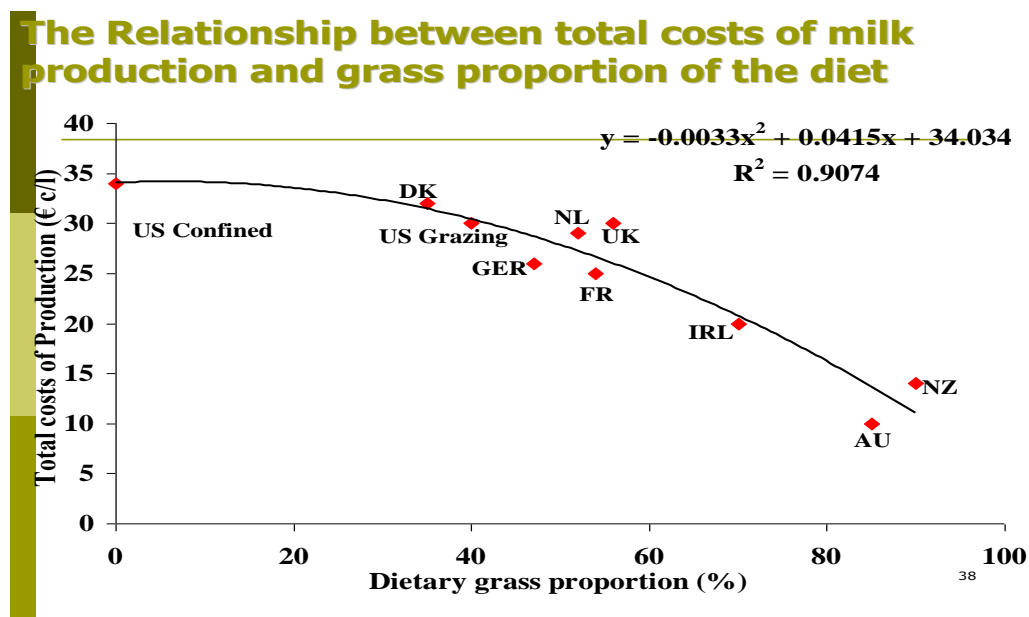
Mistake # 5 (cont) If this farm can do this then that farm can do it too

5.2 Composite inputs treated as a single input

The Composite Input Problem



But this sort of thing would never happen, would it?
 What are we supposed to make of this....



-this relates a composite inputs- grass % - which is a result of many input response functions in the whole farm, across farms and across countries, to the flawed

concept 'average cost of production', estimated across farms in different countries and adjusted for exchange rate differences

- Individual farm businesses in each of these countries earn high and low returns to capital, using a range of the possible systems in that country
- Milk prices paid in each country tells the marginal cost of producing milk in that country
- Asset values reflect profitability of an activity in any country
- Exchange rates are big determinants of competitiveness

But first, how do we assess how well a farm business is performing? Ultimately, the test is how well the business is helping the owners to achieve their goals. Having a look at the farm business from three angles:

1. Efficiency (Profit)
2. Liquidity (Cash)
3. Wealth (Equity, Net Worth)

tells us about how well the business is contributing to meeting some important goals of farm families, such as building wealth, making best use of resources managed and paying the bills.

Benchmarking/Comparative Analysis

Benchmarking involves calculating many partial average ratios measuring output from various input parts of the farm business. For example, average output per hectare or per cow or per labour unit. But to assess how well a dairy business is performing or will perform means looking at the whole system – not just some parts of it.

Judging the past or expected future performance of the whole farm system is done in terms of return on total capital (called economic efficiency), net cash flow after debt servicing (called liquidity) and growth in equity (called wealth).

Judging whether a change to the farm business is worth doing involves looking at how the whole business looks with and without the change; or, the gains from all the changes minus the costs of the changes, assessed as expected extra returns as a percentage return on the extra capital invested.

Common partial analyses (also called benchmarking or comparative analysis of technical efficiency standards), such as average milk/cow, average milk/ha, average cows/labour unit, average pasture dry matter consumed/ha and so on, do not tell whether a business is economically efficient, liquid or adding to wealth, or whether a change will earn a satisfactory return on marginal capital.

Average ratios measuring technical efficiency in terms of particular output/input ratios for a farm system tell nothing about whether a farm system is profitable, or how it could be made more profitable by adding a bit more or something or using a bit less of something else.

Partial measures can be high or low and be the most profitable level in any system, depending on the other resources and on prices of output and costs of resources.

Depending on which technical ratio is used, they can give logically opposite conclusions. For example, one guide might be 'maximize production per cow'.

Another guide might be 'maximize production per hectare'. Following the first guide would involve reducing the number of cows. The second guide would tell to increase the number of cows. Logically opposite advice. The right advice is maximize profit per farm, based not on physical production measures but costs and returns.

The performance of whole farm systems are made up of numerous input/output relationships – fertilizer to pasture DM, water to pasture, labour to cows, cows to hectares, pasture plus purchased feed to milk. Each farm has its own set of these relationships, called response functions or production functions.

These biological response functions are subject to the operation of the principle of diminishing marginal returns: as more and more of a variable input is added to a fixed input (e.g. water to irrigation bay of pasture, nitrogen to pasture, cows per hectare, feed to cows), the addition to output from each extra unit of input diminishes. The extra output is called marginal product. When changes are made to a system, the extra output from the response functions is the relevant change in output, not the average output, because diminishing marginal returns means the marginal change will be different to the average output from all inputs. This means average measures do not tell about marginal output from a change in input. This means average technical ratios of input to output are not useful to assessing a change in a system.

As each farm has its own set of response functions for inputs to output, measures of average technical ratios for a number of farms, such as average pasture consumed per hectare or average concentrates fed per cow, cannot be usefully compared between farms. For example it is sometimes said: farm A has a technical efficiency ratio of X and makes Y output and makes \$Z profit. Farm B has a technical efficiency ratio of $1/2X$ and makes $1/2Y$ output and makes $1/2Z$ profit. Therefore, if farm B operated with technical input ratio of X it too would make Y output and make \$Z profit. But the response function of input Z to output Y of farm B is different to that of farm A. It is thus a fantasy to imply farm B could achieve the same results as farm A *because they are operating on different input:output production functions*. Further, to draw a line of causation from 'making output Y to making profit \$Z' is simply not the whole story. A part of a system does not contribute the whole of the profit (Profit is only sensibly expressed as a return to all inputs, such as return to total capital).

A farm system with high average technical input:output ratios may indicate a farmer doing a terrible job with terrific resources or a terrific job with terrible resources.

With diminishing marginal returns to variable inputs, maximizing total product from the fixed inputs, or maximizing average output per unit of input, or minimizing average cost per unit of output, will not maximize profit.

A farm system may have good (or bad) average technical efficiency ratios for inputs to outputs for say last year and this may simply be because it rained (or didn't). The decision about how much input to use is made before the output results, and the output that results is in part determined by random events such as rain or hail or heat or disease and so on. Management intentions and outcomes are not the same thing. A farm system might rank in the top 10% or the bottom 10% of a population of farmers in any year as a result of no change in system and purely random events under no control of the manager.

The resources of each farm system are unique, e.g. starting with the farm family: the farm owner manager, goals, skills, experiences, stage of life, attitude to risk, number of children – all unique. Farm history - unique. Mix and layout of soils, slope and aspect, fertilizer history of pastures, species genetic makeup and of plants and animals - unique. All these unique resources combine to produce a return on capital from the combination of response functions unique to the system. Information about single points on other farm's response functions are of limited relevance to explaining performance of a different farm and even less to making decisions about how to change a different farm.

In Sum

Benchmarking information is not much use for assessing farm performance in the past or in a changed future, because:

- Farm systems are unique;
- Whole farm profit, cash and wealth indicate performance, not partial indicators;
- Response functions are different on different farms, making technical ratios achieved on one farm unattainable on another farm;
- Benchmarks are average partial technical measures when total whole farm profit, cash and wealth measures and measures of marginal input:output changes are needed;
- Implied cause and effect of average technical ratios and whole output measures are just that - implied, not proven. Correlation is not causation;
- A wide range of average technical measures – high to low - can be consistent with maximum profit;
- Output to input quantities are also determined by timing and random chance, not management alone;
- It is impossible to infer marginal changes from information about average levels of input:output performance;
- Farm management is about the future not the past;
- Farming is about changing to new production frontiers, and re-organising marginal resource use;
- Averages are artificial constructs;
- Averages do not enable optimising decisions;
- Aggregation of inputs and outputs is fraught with problems of measurement;
- Changes in valuation of livestock changes rankings of livestock activity gross margin;
- If differences in activity gross margins are small, error in the estimates will mean no sensible conclusions are possible;
- Labour is often used because it is free;
- Technological change over time moves operations to new cost levels;
- Some farms are growing, some are static, and the average is an average of these - individual trends are more useful;
- Average cost is a year round average but seasonal variations and price variations occur;
- Comparative analysis may suggest a weakness but does not determine the cause of the weakness;
- Benchmarks should be ones that you can control, and be related to profit;
- Diminishing returns and complementarities are important;
- Ratio comparisons resulting in significant deviations 'from the norm' reflect only symptoms of a problem. Further analysis of the financial information and

investigation into the operation of the business as required to isolate the causes of a problem;

- The timing of the data used to form ratios is critical, as also is any inflation effects on values;
- There are no benchmarks for new technology, when farming success is much about moving onto new production functions.

There is no substitute for proper whole farm analysis of the choices the farmer faces: walk the farm, understand the human and technical and risk elements, work out the economic and financial performance of the whole farm business. This is done for the recent past as a basis for analysing how the farm business might perform in the relevant planning period, such as the next few years, with and without potential changes to the system.

PAPER NO.2

Farm Management Economics Refresher Day

1/ Profit, Cash, Growth

First, we'll run through the approach to assessing farm performance that is being standardized across the various State data collection agencies, and is the approach used in the new Dairy DataPoint (Gardiner) where farm data from the States (Vic DPI Dairy Monitor, Qld, Tas) will be assembled along with data from co-operating consultants (raw data, transformed into the standard format for assessing farm performance).

The Method

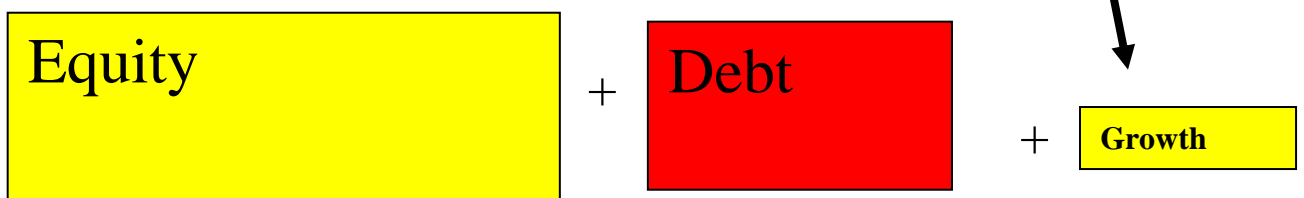
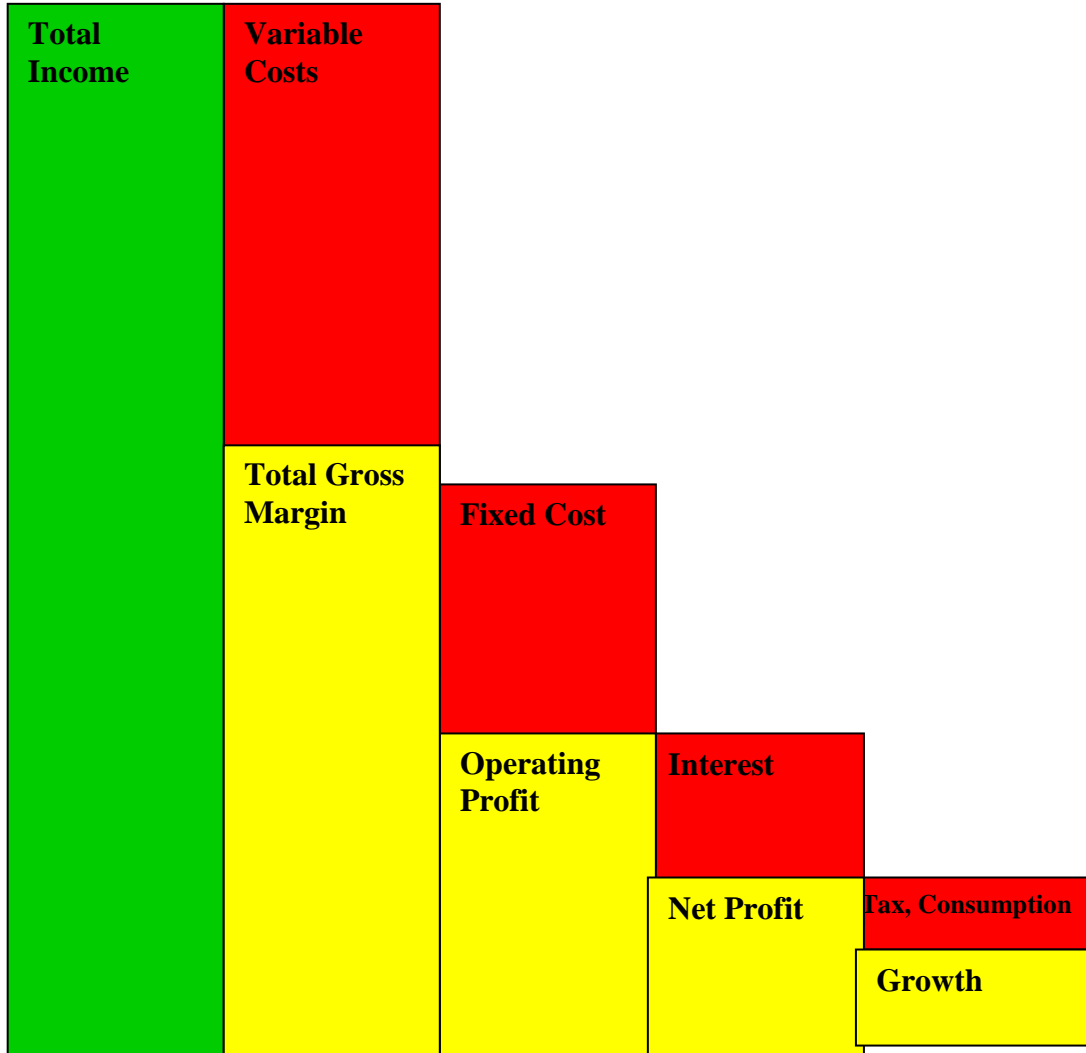
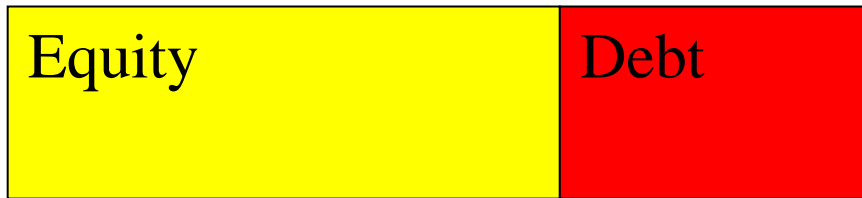
The method of farm performance assessment has the aim of clearly separating economic efficiency (profit, return on capital managed, return on equity) and financial liquidity (net cash flow before and after debt servicing). Most commonly these two measures - profit and cash - have been confounded, achieving the inglorious double of getting conclusions about both profit and cash wrong. The aim of clearly separating and correctly measuring profit and cash is that farmers will know clearly (i) how well their business is performing in terms of efficiency and (ii) whether they can pay their bills.

A feature of this method of estimating true profit and true NCF is that it also makes possible to estimate change in wealth (Growth, Increase in Net Worth or Equity), without having to also construct a balance sheet at the start of the production year and at the end (though this can be done as a useful check on the sums). This feature, focus on change in wealth, is as valuable as efficiency and liquidity when it comes to assessing business performance against farm family goals. At another level, we are trying to lift the narrow and blinkered industry focus on measures of technical efficiency (productivity estimates) to the more useful measures that relate directly to farmer goals: profit, cash flow, wealth. (Note: in good years, with high prices, productivity goes down as profit, cash flow and change in wealth goes up!).

The diagram illustrating the approach to estimating true profit, true cash and change in wealth is shown over this page.

Once the farm data is in the form outlined, then, if this does not tell you what you want to know, any number of manipulations can be done to gain insights. For example the DuPont method of business performance analysis explained in the appendix lends itself to using these measures calculated here. They make good use of Operating Profit (EBIT) relative to gross revenue, as some indicator of costs, and Gross revenue relative to total assets used, as some indicator about yields. The DuPont approach appeals to some analysts – those who think well in ratios, using them to compare and contrast with similar sized businesses, compared to the (mostly) whole numbers approach shown above.

Total capital at start.



Total cash in	Cash out before principal and interest	
	Cash flow before principal and interest	Principal and interest
		Net cash flow after principal and interest

2/ Analysing a simple change

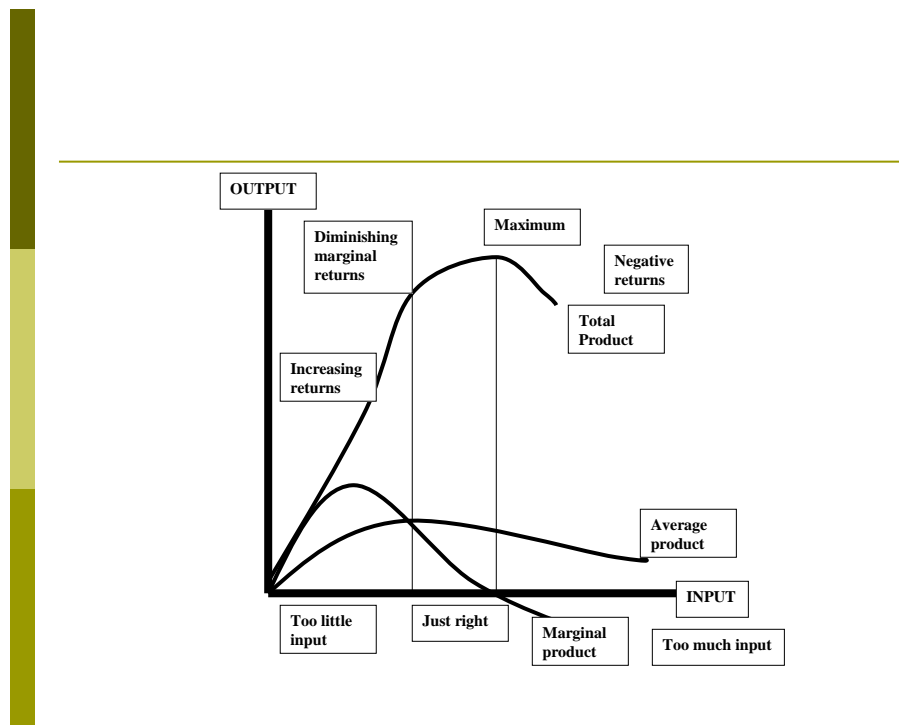
The traditional approach is the annual steady state partial budget, subject to sensitivity testing. This is often sufficient. See example 2.

The annual partial budget doesn't quite capture true return to capital as it does not take account of less profitable periods during the transition time to the steady state, or say declines in profit in later stages of an investment.

Partial budgets are not effective when the change is significant enough to have many and large effects on the whole farm - generally then it is more useful to compare two whole farm budgets, with and without the change.

The partial budget is the way to go if using a calculator and a bit of paper. If using a spreadsheet, it is almost as easy to do a full discounted cash flow budget estimating the return to the investment (IRR) and, simultaneously, estimating the cash flow and financial feasibility of the plan, as well as the contribution to wealth (NPV), along with easy sensitivity testing of the impact of risky variables.

3/ Marginal analysis of decisions about feeding dairy cows



The method for analysing production function data has been long established but until now rarely used (not least because we rarely have good production response data). The Ellinbank PMR-milk response experiments have given us some production functions to work with. See exercise three for the method.

The key to this analysis is understanding two things: -first, the profit maximizing level of variable input (if capital is available) is to use the input as long as it adds to profit. That is, use it up to the level where the extra return from an extra unit of input just equals the extra cost of that input (this is called 'where marginal cost equals marginal returns'). All previous units of input add something to total profit.

Marginal return is Price of milk (fat and protein) * marginal product (amount of extra milk) from an extra input

Marginal cost is cost of the extra unit of input * the quantity of the extra unit of input

The equation for $MR=MC$ can be reformed into $MP=P_x/P_y$. That is the marginal product=the ratio of the price of the input to the price of the output.

As it happens the marginal product is the slope of the production function. So to find the theoretical profit maximizing level of output, just need to find where the ratio of the price of input to output equals the slope of the production function.

This can be done using arithmetic (an approximate answer), geometry or algebra. Graphically, draw a line with the slope of the price ratio that just equals the slope of the production function (see attachment A).

Using algebra and geometry, the marginal product or slope of the production function is the first derivative of the equation for the production function. So you just solve the equation for the first derivative of the equation for the production function as being equal to the ratio of the feed price to the milk price (see attachment B).

In practice

There are many factors affecting what production function a cow will be operating on over any time period, so the theoretical optimum are just guidelines for thinking about how to answer the question: how much feed to give the cow?

A handy additional calculation is to work out how much each extra unit of feed returns, like an investment. For example, the extra feed costs \$0.30 and adds \$0.60. The return on the extra capital is $(60c-30c)/30c = 100\%$. This is a good investment. The next unit may add 40c worth of milk. The return on this extra cost is $(40c-30c)/30c=33\%$. Given, the errors and uncertainty about the estimated production function, this may be worth doing. It might not be a good bet if the unit of feed that adds only say 33c is worth the risk, $(33c-30c)/30c=10\%$.

An aside on Average and Marginal Product, which can be interpreted as average and marginal FCE

Much is made of average FCE in dairy nutrition – over some time period. As it happens, the FCE of a unit of feed is equivalent to the average or marginal product derived from a production function (see production function graph). While average FCE over a whole lactation may tell something about the merit of different alternative feeding regimes, the average product, or average FCE of feed, for a time period within a lactation is not a sound guide to how much to feed. The correct guide is marginal product-aka-marginal FCE. As the production function figure shows, maximizing average FCE of a feed input during a lactation will not maximize profit (marginal FCE=ratio of price of feed to price of milk is the rule).

The logic of the biological response function is that if you feed to maximize the average FCE of a feed input, you will not maximize profit. (Indeed, production economic theory says that, if the product is worth producing at all, inputs should be used up to where the average product is maximized, *regardless of the cost of the input*, because each added input is raising the average output of all the previous

inputs!). Just as operating to maximize average product of a variable input will not maximize profit, minimizing average costs will not maximize profit either- for the same reasons. A common rule: maximize margin over average feed cost also will not maximize profit.

The logic of the biological response function is that the **minimum** level of feeding ought to be up to where the average product, average FCE is maximized. At the other end of the scale, the maximum level of feeding would be where total product starts to decline and marginal product becomes negative. Beyond this you can get the same output with less input, so that makes no sense. And, you'd only feed to where total product is a maximum if the feed was free. Hence, in the real world, the optimum quantity of feed to use is somewhere between where average FCE is a maximum and where total product is a maximum; now we need dollars to decide precisely - where the extra revenue equals the extra cost. This will be at a marginal FCE lower than the average FCE. That is, lower marginal product (marginal FCE), and lower average product (average FCE) gives higher profit than the level of feeding that maximizes average product.

4/ Risk Analysis

The main forms of incorporating consideration of risk in an analysis is to (i) test sensitivity of the outcomes to volatility of key variables (ii) investigate the combined effects of various levels of key variables occurring at the same time, called scenario analysis and (iii) using probabilities in tests i and ii above, and/or using probability budgeting methods to estimate the mean and variance of outcomes of changes to farm plans. This type of analysis involves estimating probability distributions of key variables and calculating joint probabilities of events and their affect on outcomes. The spreadsheet add-in program @Risk can be used to do this type of analysis.

The formal probability budgeting methods can be used to rank alternative changes to farm plans according to their mean and variance (riskiness). These results can be presented to the decision-maker remembering it is the decision-maker's estimates of the likelihood of events occurring that are in the analysis. Establishing well informed estimates of probability distributions is not a simple task, especially once correlated effects between random variables become part of the question. The decision maker can then weight up the riskiness and returns of an option according to their attitude to the risk vs return situation the option represents. (This is called the passive approach to allowing for attitude to risk). More formal and complex approaches that include degrees of risk aversion are also available but given the almost impossible task of working out someone's attitude to risk in a numerical way, the methods of formally including attitude to risk seem best placed to be used at the research level, e.g. at a generalized level, if someone was x degree averse to risk, then option A would suit them better than option B, and so on.

Used well, for major strategic decisions involving considerable risks and volatility of potential outcomes, the use of probability budgeting can be a valuable additional source of information for advisors and their clients.

However, the more elaborate risk analysis methods, if used with poor understanding of risk, probabilities, attitudes to risk, the difference between variables that are random and those that are simply unknown, and decision theory, can mean the elaborate probabilistic budgeting techniques carry their own set of risk of generating poor quality information, leading ill-informed decisions - or less well informed decisions than the very powerful, well understood, simple budgets that are really

well worked over for sensitivity and a small number of well thought out scenarios.
The process of the budgeting is the key to informed decisions.

Appendix One

DuPont Financial Analysis Model

A Process For Knowing Where to Spend My Management Time Tomorrow Morning After Breakfast

By

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UW Center for Dairy Profitability**

Our computer technology today provides wonderful opportunities to collect, manipulate, and process data including financial analysis data. Sure, it gives a manager lots of numbers, but what do they mean in terms of where to spend my creative management time tomorrow morning after breakfast?

There is no lack of ratios to calculate from financial data, each of which is a valuable piece of information to the manager. The Farm Financial Standard Council's sweet 16 ratios (recently expanded) have been a standard for years in helping farm managers evaluate their financials. However, over several years of teaching undergraduate students and Extension clientele I often found it difficult for people to wrap their arms around what the ratios were indicating and ultimately where to spend their valuable management time. The challenge often led to indifference by the undergraduate students and a lack of seeing any value to go further by Extension clientele.

The DuPont system for financial analysis is a means to fairly quickly and easily assess where the business strengths and weaknesses potentially lie and thus where management time may optimally be spent. It is not the only nor the most thorough, but it is a fairly straight-forward and systematic means to drill back into the financial numbers to determine the source or lack thereof for financial performance.

A colleague, Gregg Hadley (UW-River Falls), summed up well the DuPont system in a recent article on E-Extension (The DuPont Analysis: Making Benchmarking Easier and More Meaningful, Updated June 10, 2009, http://www.extension.org/pages/The_DuPont_Analysis:_Making_Benchmarking_Easier_and_More_Meaningful):

If we are lucky enough to have the minimum number of financial documents needed to conduct a meaningful financial analysis (both beginning and ending balance sheets, either an actual accrual or accrual adjusted income statement, and a statement of cash flows), we are then inundated with pages and pages of intimidating numbers to sort through.

This gives many managers and advisers a justification not to give their financial records anything more than a passing glance. This is unfortunate. A good financial performance analysis should do more than inform about how a farm performed in the past. More important, it should provide the manager and adviser with insight regarding how to prioritize activities that will enable the farm to improve its financial performance.

The DuPont system has disadvantages as does any financial analysis system. However, its advantage beyond simplicity of use is that it takes into account the major levers of firm profitability – efficiency, asset use, and debt leverage.

Anatomy of Profits

Before describing the DuPont system, consider the anatomy of profits.

The accounting equation is:

$$\text{Total Assets} = \text{Total Debt} + \text{Total Owner Equity}$$

As the accounting equation shows every penny of assets comes from one of two sources – that financed by debt (borrowed capital) and that financed by equity (the owner's own money). Assets can also be described by those that are capital assets versus short-term inventory or market assets. Capital assets are longer-term investments (land, machinery, breeding stock, etc.) that are not sold themselves to make profits, but are put to work to produce marketable inventory that can be sold for profits (feeder cattle, eggs, etc.). Inventory also includes inputs such as feed, seed, and fertilizer.

Businesses earn profits by mixing their labor and management with inputs and capital assets to produce goods for sale. The DuPont system recognizes this recipe for profit-making and segregates it into three distinct components or levers:

1. Earnings (or efficiency),
2. Turnings (effective use of assets), and
3. Leverage (using debt to multiply earnings and equity)

In the DuPont system one can drill back into these three levers to determine where profit performance is coming from and potentially determine where management time should be spent for improving profits. Specifically DuPont measures:

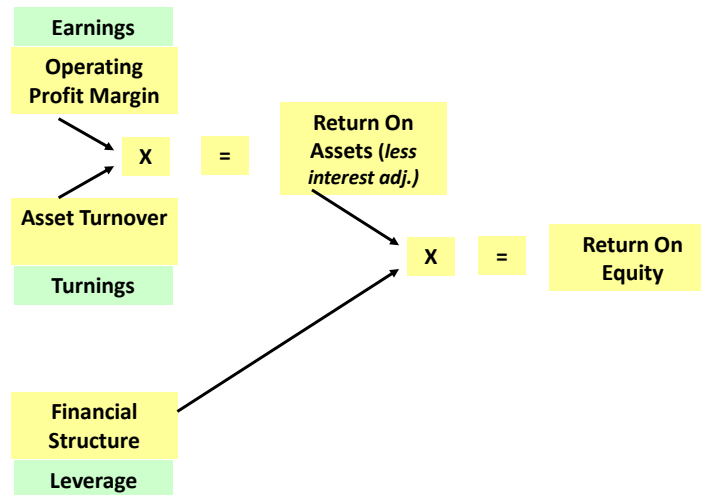
1. How efficiently inputs are being used to generate profits [Earnings]
2. How well capital assets are being used to generate gross revenues [Turnings]
3. How well the business is leveraging its debt capital [Leverage]

Figure 1 shows a graphic of the DuPont system. It begins on the far right side with Rate of Return on Equity (ROROE). High ROROE is the prize in the DuPont system. ROROE is calculated as:

$$\frac{\text{Net Income from Operations} - \text{Unpaid Labor \& Management}}{\text{Total Owner Equity}}$$

The financial manager can then drill backward to see where ROROE performance either is, or is not, coming from.

Figure 1: DuPont System



Starting on the upper side ROROE, in-part, comes from how well the business is earning profits from its assets as measured by the Rate of Return on Assets (ROROA). ROROA is calculated as:

$$\frac{[\text{Net Income from Operations} + \text{Interest} - \text{Unpaid Labor and Management}]}{\text{Total Assets}}$$

It makes sense that the higher the ROROA the higher the ROROE. In-turn, the ROROA comes from two components or levers of profitability.

One is how efficient the manager is in turning inputs into outputs, or in a financial sense, how efficient the manager is in turning the gross revenue of dollars coming into the business into net profits that are kept in the business after all expenses are paid. This is the “Earnings” lever and is measured by the Operating Profit Margin Ratio (OPMR). The calculation is:

$$\frac{[\text{Net Income from Operations} + \text{Interest} - \text{Unpaid Labor and Management}]}{\text{Gross Revenue}}$$

Interest is added back so that the measure you get is one that measures efficiency of operations regardless of the debt structure. Debt structure effects will come into the system later. In situations where there is unpaid labor and management it is deducted to recognize the value of the labor and management. The more efficient you are in turning gross sales into profits that you keep the higher your Rate of Return on Assets and ultimately the higher your Rate of Return on Equity.

The second source of ROROE is how well you are using the assets of the business. This lever is referred to as “Turnings” meaning how well you are turning assets into production and sales of product. To use an extreme example, if you had a 300 acre farm (all tillable) that you left sit idle then your performance of turning assets into production and sales of product would go way down. The “turnings” lever is measured by the Asset Turnover Ratio (ATO). The calculation is:

$$\frac{\text{Gross Revenue}}{\text{Total Assets}}$$

The better able you are to use the assets you have to produce and sell product the higher the Rate of Return on Assets will be and the higher the Rate of Return on Equity.

The last lever is “Leverage,” which is also known as “Equity Multiplier”. Before going further with the explanation of leverage, it is worth backing up a step and exploring the accounting equation again

$$(\text{Total Assets} = \text{Total Debt} + \text{Total Equity}).$$

Given this equation, which is true for every business, then any profitable return to the use of assets is a profit return to the assets financed by debt and to those financed by equity. Equity is fairly straight-forward, if you invest \$100 of your own money and earn \$10 back then your equity has returned 10% (10/100). For the return to debt it is a bit more complicated because you have to pay someone for the use of the debt – interest. So, the question becomes whether or not the debt you have is returning a profit larger than the interest you have to pay for using that debt. If it is then the leftover profit after paying interest is an additional return to your equity. That is, if I’m paying 8% interest and my profit return on the debt is 10%, then I not only can pay my interest, but I have 2% leftover that I get to keep. This 2% becomes and increase to my equity. This is why the debt or leverage component of DuPont is sometimes called an “Equity Multiplier.”

It may seem an odd statement to make for some, but if you want to increase your ROROE then one way to do it is to increase your debt! The trick is that the debt must be managed in a way that returns a profit greater than the interest rate. If it is not then the equity multiplier still works, just in the wrong direction!

Ultimately the leverage lever is measured by the Debt to Asset ratio (D:A), which is calculated as:

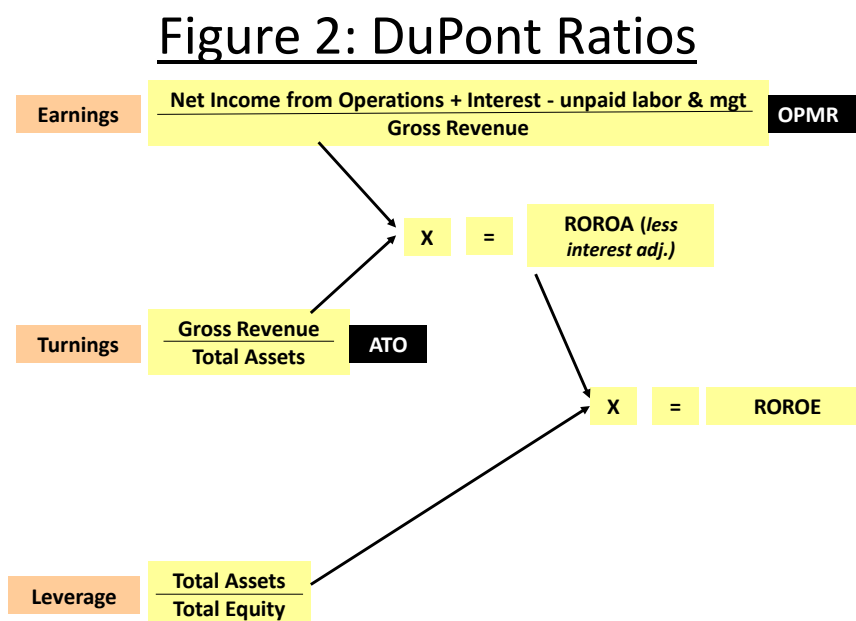
$$\frac{\text{Total Debt}}{\text{Total Assets}}$$

For ease of the math in the model, the leverage lever can be expressed as:

$$\frac{\text{Total Assets}}{\text{Total Equity}}$$

The greater this ratio then the more the proportion of debt is in the mix of assets. If the assets financed by debt are earning a return greater than the interest rate, then the higher the ratio the greater the Rate of Return on Equity.

Figure 2 shows the same DuPont model with the ratio measures.



Note, the interest rate adjustment in the ROROA box is the adjustment needed to return the cost of interest before measuring the Rate of Return on Equity. Recall that interest was taken out when calculating the OPMR.

The DuPont system as illustrated allows you to identify where profit performance is, or is not, coming from in one or more of three areas. Once identified then the next step is to drill back into the numbers that make up the ratio of concern.

For example, if the OPMR is found to be lower than the manager would like it to be then look at the numerator of the OPMR (net income from operations + interest – unpaid labor & mgt) to determine what might be the problem, particularly expenses. Compared to your more profitable peers what are your labor, vet, repair, and other input costs?

If the performance problem appears to be coming from a low ATO then the manager might drill back into the business assets to see how well they are being used. Are there dead assets in the business (ones not being used to create product for sales),

does the business have excess machinery capacity, or are there assets that are under productive (poor weight gain, breeding cycles too long, sickness, death loss, etc.).

If the debt structure is low, that is debt is not leveraging equity as much as peer businesses, then the manager might drill back and question how debt is being used. Could additional debt be used to improve facilities, machinery, etc. that ultimately pays for itself in higher production and sales or does debt that is not productive need to be paid off (or perhaps the assets sold).

As with all financial analysis systems the model is only as good as the numbers that go into it, that is, garbage in then garbage out. Another valuable piece of information to have to evaluate DuPont is benchmarks of profitable peers. There are general ranges for each of the ratios, but each industry and your size within an industry makes a difference as to what is “good” for the ratios. Finally whether you rent or own the assets you use in a business also makes a difference in the interpretation of the ratios.

Appendix A provides a brief example of using the DuPont model.

It is often said that management is part science and part art. The DuPont system has both elements. The ratio calculations are science and just a manipulation of numbers. The art is interpreting the ratios and drilling back into where the ratios indicate there could be challenges and thus information of where to spend your creative management time tomorrow morning after breakfast.

Appendix A

Brief Example (Adapted from an example from Texas Tech University)
<http://www.aaec.ttu.edu/faculty/phijohns/AAEC%204316/Lecture/notes/DUPONT.htm>

Table 1. DuPont Analysis for Two Farms

	<u>Farmer A</u>	<u>Farmer B</u>
1. Operating profit margin ratio (OPMR)	0.30	0.12
2. Asset turnover ratio (ATO)	0.20	0.36
3. ROROA (1*2)	0.060	0.043
4. Interest expense to avg. farm assets	0.05	0.03
5. Equity multiplier	2.00	1.50
6. ROROE (3-4) * 5	0.02	0.02

Farmer A and Farmer B each have a 2 % ROROE. However, the levers of the DuPont system indicate that the sources of the weakness are different. Farmer A has a stronger operating profit margin ratio but lower asset turnover compared to Farmer B. Furthermore, Farmer A has a higher leverage ratio (equity multiplier) than Farmer B.

The weak ratios for each farm may be decomposed into components to determine the potential sources of the weakness. To improve asset turnover Farmer A needs to increase production efficiency or price levels or reduce current or noncurrent assets. To improve profit margins, Farmer B needs to increase production efficiency or price levels more than costs or reduce costs more than revenue.

The DuPont analysis is an excellent method to determine the strengths and weaknesses of a farm. A low or declining ROROE is a signal that there may be a weakness. However, using the DuPont analysis can better determine the source of weakness. Asset management, expense control, production efficiency or marketing could be potential sources of weakness within the farm. Expressing the individual components rather than interpreting ROROE itself may identify these weaknesses more readily.

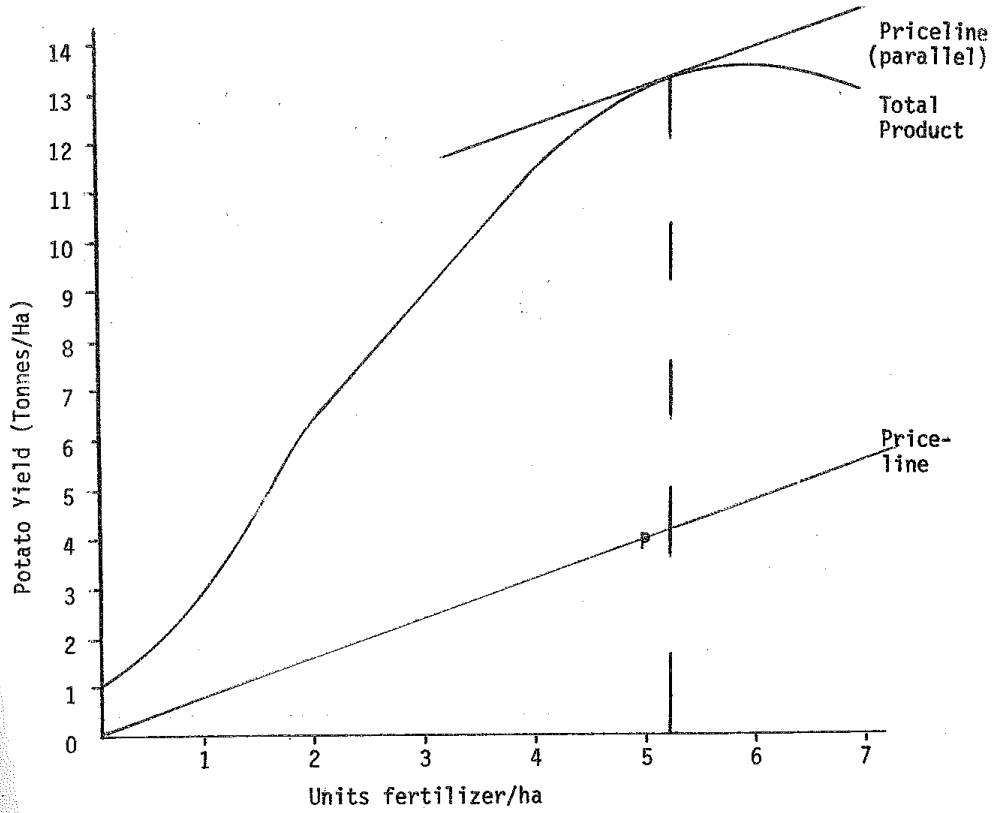
Appendix B

Maximum Profit: $FCE = \text{Price Feed} / \text{Price MILK}$

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Figure VI(G)

FITTING A PRICE LINE TO A TOTAL PRODUCT CURVE



right throughout the fifty years under review.

There is also evidence around this time of application of another approach to the analysis of farm production decisions, and one which was to be similarly enduring, the production economics way of thinking. Geddes (1942) applied fundamental economic principles to dairy cow rations, principles which he said had been around, but not widely used, for many years. There followed an explanation and demonstration of the calculation of balanced, cheap feed mixes for milking cows based on feed starch and protein equivalents and the costs of various feed components, by solving a number of simultaneous equations. This represented an early attempt at deriving least-cost feed mixes, a question which was to be resolved within the next decade by linear programming. Geddes (1942, p.68) cited some examples of possible savings on feed costs, which can be achieved via the economic approach, and threw in a bit of practical advice as well, viz:

There are pitfalls in the purely economic approach to dairy cow rationing. Any scheme which disregards the fact that the cow is a biological organism and seeks to put her on the unvarying plane of efficiency of the machine, is likely to break down. The old steam engine analogy is not yet out of date; a lot depends on the stoker. Yet the economic approach, properly adapted, has a useful contribution to make to dairy cow feeding.

Geddes (1943) also wrote about the economics of pig production; specifically, the structure of pig production costs. This included analyses of the economics of pig production on milk, as a sideline to the dairy industry, and as a grain-based independent activity. Geddes made the pertinent observation about supplementary or sideline enterprises and the difficulties with cost-accounting approaches to analysis of farm management and efficiency. That is, the costings may show that a particular sideline activity is unprofitable, 'in spite of the fact that the farmer would be worse off if he were to discontinue

Paper No.3 Exercise 1

Read the details of the likely operation for the coming year of the case study dairy farm and advise the farm family about the likely performance of the business in terms of Efficiency, Liquidity and Growth.

Efficiency is Return on Total Capital Managed

Liquidity is Net Cash Flow before and after Debt Servicing

Growth is change in Equity (Net Worth) by end of the year

Profit and Growth		
Total Income	Milk Income	\$ 1,250,000
	Stock trading profit/loss	\$ 89,375
Variable costs	Herd, shed, feed costs, operating repairs and maintenance	\$ 750,000
Overhead costs	Paid labour, repairs and maintenance & administration	\$ 225,000
	Depreciation	\$ 49,700
	Owner/operators' allowance	\$ 100,000
Finance costs	Interest	\$ 240,000
	Lease	\$ 50,000
Tax	Tax	\$ 0

Cash:		
Cash In :	Milk Income	\$ 1,250,000
	Stock Sales	\$ 89,375
Cash Out :	Herd, shed, feed costs, R&M	\$ 750,000
	Paid labour, & administration	\$ 225,000
	Personal drawings	\$ 100,000
	Interest	\$ 240,000
	Lease	\$ 50,000
	Principal	\$ 300,000
	Tax	\$ 0

Balance Sheet:	
<i>Opening values</i>	
Total land area value (leased + non-leased land)	\$ 7,500,000
Livestock	\$ 760,000
Plant and equipment	\$ 710,000
Total value of leased land	\$1,000,000
Debt (liability) (10 year Term Loan, just started)	\$ 3,000,000

Exercise 2

Example exercise analysing a change

Analysing a Simple Innovation: A First Look Budget of a Single Production Period, Steady State

Analysing a simple change to a farm can be done by constructing a budget of the operation of the farm as it currently operates and then comparing how it would operate with the adoption of an innovation, once the change is fully operational. This situation is called the steady state. If the business looks likely to be more profitable with the change than without the change, then the change is likely to be worth doing. As well, the net cash flow after the change has to be adequate to cope with added financial demands resulting from the change. The addition to net worth likely to result from the change has to look attractive.

There are two ways of investigating the situation of a farm business with change and without change. One way is to construct annual budgets of the whole farm for the situation without the change and the situation with the change, and compare expected operating profits for the two situations. Another, more common technique for evaluating a simple change, is to look at only those parts of the whole business that will change. This partial approach involves looking at all the favourable aspects of the change and balancing them against all the unfavourable aspects that result from the change. As many as possible of these elements are given a dollar value. Extra costs and extra returns and net gain are estimated to indicate how much whole farm profit is expected to increase after the change.

Regardless of the nature of the change, the impacts have to be assessed in terms of the effects on the whole farm. The marginal way of thinking dictates that the perspective to use when considering a change is 'What might be the situation if the change is not made?' compared to 'What might be the situation if the change is made?' Take the case of the simplest change: a new activity is added without any change to the existing farm business. The merit of a simple change such as this to a farm business can be assessed using the partial budget approach, and looking at the situation of a typical production cycle, such as a year of operation of the change performing at the expected 'steady state' level and:

- Estimating the value of all the expected extra costs that can be given a monetary value;
- Estimating the value of all the extra benefits that can be given a monetary value;
- Subtracting expected extra costs from expected extra benefits to get net benefits;
- Expressing expected net benefits as a percentage of the extra capital invested to give the expected return on extra capital;
- Compare the expected return on extra capital with the potential returns from investing the same capital on some other use;
- Investigating the effect of changes to key variables such as yields and prices on the key criterion.

In a partial budget, extra profit of a simple change is expressed as a percentage return on the additional capital invested. This is done for the time when the effects of the change are fully realised and the plan is fully operational. This takes no

account of the costs incurred between initial set-up and steady state, the effect of time on cash flows up until the steady state. (If the change is complex and involves more than a year or two, the steady state partial budget is inappropriate. Budgeting over the years of the life of the change and net cash flow analysis and discounting is needed).

In a more likely case of a simple change than the case discussed above, innovations are likely to affect some of the things currently being done on the farm. For example, a new activity replaces an existing activity. In this case there are likely to be some net benefits from the 'old' activity that will no longer be generated. There will be some benefits foregone, some costs saved, and some net benefits given up. These affects must also be counted in evaluating a change to a farm system. The approach in this case is:

- Estimate the expected net benefits from the new activity (A);
- Estimate the net benefits from the 'old' activity (B) that will be foregone if the change is made;
- Deduct (B) from (A) to get (C), the net gain from the change;
- Express (C) as a percentage of the extra capital invested in replacing the old activity with the new activity;
- Check effects of variability of key variables on results.

The variable nature of the weather and agricultural markets means that no farm plan is likely to work out as expected. So, it is necessary to work out what would happen if prices or yields or interest rates were either worse or better than expected, and the break even levels of key parameters. The percentage chance (or probability) of these events happening can be evaluated.

Example Partial Budget (Expected Costs and Income in most likely, current dollars)

The case study farmer in exercise 1 wishes to analyse the idea of leasing the 50 hectares of irrigated dairy pasture land, and 20 hectares of dryland, adjoining his farm. The farmer has provided the following details:

The irrigated pasture land is valued at \$8000/ha and the dryland is worth \$4000/ha. The extra land can be leased for 5% of its market value.

The 50 ha of improved dairy pastures, which, managed well will supply 500 t DM of grazed and conserved pasture. This, with an additional 1 t/cow of purchased feed, will enable an extra 100 cows to be milked, producing 500 kg MS/cow. Milk price is \$5/kg milk solids and purchased feed costs are \$250/t. The 20 ha of dryland will carry 1 cow/ha over a year and suit growing out yearlings to springing heifers. Livestock trading profit is \$100/cow.

To milk the additional herd, the aged current milking infrastructure will need to be modified and renovated. This capital investment will be \$200,000, written off over 15 years. Upgrading of laneways, fences and stock troughs cost \$20,000.

Extra labour required will be one full time hand, costing \$50,000 p.a.

It will be necessary to purchase a herd of 100 extra mixed age cows (2yo-5yo), which will have a capital cost of \$1200/hd, plus 20 yearling replacements worth \$600/hd.

Extra annual Pasture maintenance and fodder conservation is \$400/ha.

Extra annual water costs are \$50/ML (medium term average for temporary water).
10ML/ha/yr applied.

Extra annual Herd costs are \$85/cow.

Annual Shed costs are \$50/hd for the extra cows (shed costs for existing herd same as before the renovation of the shed).

Extra annual R&M on new block fencing and water points and existing plant will be \$5000 p.a.

Tax rate is 20 cents in the marginal dollar.

The capital needed to make the change has a real opportunity cost (e.g. other investments on the farm) of 10% real (this includes some allowance for risk).

The task is to construct a partial budget and analyse this proposal, based on one year of production at a 'steady state' level. To do this, calculate real return on marginal capital after tax.

Then, consider factors that are not well captured in the partial budget analysis, but will matter, e.g. running a larger operation - implications for management, and for drought, for when the poor milk prices happen, what else?

Having done this 'first look', if the plan looks a goer, then risk and financial analysis is needed. This is about how robust the plan is under different risk situations and how to finance the implementation and operation of the plan. Borrowings required, peak debt and required length of loan are estimated.

Spreadsheet

Nowadays, the calculator based 'first look' budget can be done using a spreadsheet and, if so, then it is as easy to do a full discounted cash flow analysis of the economic merit of the proposal. That is, whole of life analysis instead of the traditional annual partial budget which looks at how the idea stacks up in the annual steady state (once the plan is implemented).

PARTIAL BUDGET SOLUTION

Number of extra cows	Head	100
Yearling replacements	Head	20
	kg milk	
Milk production	solids/cow	500
Milk price	\$/kg milk solids	5
Irrigated area to be leased	ha	50
Dryland area to be leased	ha	20
Pasture consumption	kg DM/ha	10
Livestock trading profit	\$/cow	100
Capital investment - milking infrastructure	\$	200000
Upgrade of laneways, fences etc	\$	20000
Depreciation period	Number of years	15
Pasture maintenance & fodder conservation	\$/ha	400
Irrigation water used	ML/ha	10

Cost of water	\$/ML	50
Herd costs	\$/cow	85
Shed costs	\$/cow	50
Repairs and maintenance	\$	5000
Labour	\$	50000
Lease %	%	0.05
Irrigated land value	\$/ha	8000
Dryland value	\$/ha	4000
Marginal tax rate	\$	0.2
Cows	\$/head	1200
Replacement yearlings	\$/head	600
Purchased feed	\$/t	250

Extra Income

Extra milk production	250000
Extra Trading profit (incl deprec)	10000

Total Income 260000

Extra Annual Cost

Herd Cost 8500

Shed Cost 5000

Feed Cost

Pasture maintenance 20000

Water 25000

Bought in feed 25000

Repairs and maintenance 8000

Annual Capital-depreciation 14667

Labour 50000

Lease 24000

Total 180167

Gain before Tax 79833

Tax 15967

Gain after tax 63867

Extra Capital Invested

Infrastructure (dairy) 200000

Infrastructure (lanes, etc.) 20000

Cows 120000

Replacements 12000

Total 352000

Return on extra capital (after tax) 18%

Paper No.4 Exercise 3

Marginal Analysis of Feed to Milk Response Data

ECM yield	Diet: PMR 1								
Price Input/unit (kg)	0.35								
Price Output/unit (kg)	0.4								
Price ratio = price input/price output	0.875								
Production function	$y = -0.249x^2 + 5.084x - 5.627$								
Marginal product	$y = -0.249*2x + 5.084$	First derivative of Production Function							
Equation	$y = Ax^2 + Bx + C$								
	A	-0.249							
	B	5.084							
	C	-5.627							
Input X (kg supplement/cow per d)	Output Y (kg ECM/cow per d)	Average Product	Marginal Product (MP)	Total Cost	Total Revenue	Total Profit	Marginal cost/unit of input	Marginal revenue/unit of input	Return on extra capital
5	13.57	2.71	2.594	1.75	5.43	3.68			
6	15.91	2.65	2.096	2.10	6.37	4.27	0.35	0.94	168.0%
7	17.76	2.54	1.598	2.45	7.10	4.65	0.35	0.74	111.1%
8	19.11	2.39	1.100	2.80	7.64	4.84	0.35	0.54	54.2%
9	19.96	2.22	0.602	3.15	7.98	4.83	0.35	0.34	-2.7%
10	20.31	2.03	0.104	3.50	8.13	4.63	0.35	0.14	-59.7%
11	20.17	1.83	-0.394	3.85	8.07	4.22	0.35	-0.06	-116.6%
Profit maximizing level of input	Profit maximizing level of output	Average Product	Marginal Product (MP)	Total Cost	Total Revenue	Total Profit	Marginal cost/unit of input	Marginal revenue/unit of input	
8.452	19.56	2.31	0.875	2.96	7.82	4.86	0.35	0.40	
Level of input for maximum output	Maximum output	Average Product	Marginal Product (MP)	Total Cost	Total Revenue	Total Profit	Marginal cost/unit of input	Marginal revenue unit of input	
10.209	20.32	1.99	0	3.57	8.13	4.56	0.35	0.02	
Price ratio scenarios		Price Input							
		Worst	Poor	Most likely	Good	Best			
	Price Output	0.45	0.40	0.35	0.30	0.25			
Worst	0.25	1.800	1.600	1.400	1.200	1.000			
Poor	0.3	1.500	1.333	1.167	1.000	0.833			
Most likely	0.4	1.125	1.000	0.875	0.750	0.625			
Good	0.45	1.000	0.889	0.778	0.667	0.556			
Best	0.5	0.900	0.800	0.700	0.600	0.500			

Optimum level of input and output							
Scenario	Worst-worst	Poor-poor	Most likely- most likely	Good-good	Best-best		
Price ratio	1.80	1.333	0.88	0.667	0.50		
Marginal Product	1.8	1.333	0.875	0.667	0.5		
Output (kg milk/cow per d)	17.07	18.54	19.56	19.88	20.07		
Input (kg supplement/cow per d)	6.59	7.53	8.45	8.87	9.20		
Net Benefit (\$/cow per d)	1.30	2.17	4.86	6.28	7.74		