Valuing on-farm investments

J. M. RENDEL[1], A.D. MACKAY[2] and P. SMALE[1]
[1] *AgResearch, Private Bag 50034, Mosgiel*
[2] *AgResearch, Private Bag 11008, Palmerston North*
john.rendel@agresearch.co.nz

Abstract

The challenge of maximising the value of an on-farm investment is dependent on two factors: first, ensuring the full potential of the investment is realised by adjusting current practices to capture the gains; and second, the challenge of isolating, quantifying and valuing the contribution that investment makes to the whole farm business. A new generation farm optimisation model (INFORM) addresses both these issues. Two distinctly different on-farm investments, planting of a forestry block and sowing a multi-year forage crop, both on a hill country sheep and beef operation, are presented to illustrate the capability the model has for first optimising the investment and then using this information to conduct a farm system capital investment investigation. The investment analysis includes consideration of the capital requirements, and also calculates the maximum amount that can be spent on each of the investments to add value to the current business.

Keywords: farm system analysis, investment, NPV, optimisation, INFORM

Introduction

A capital investment can be thought of as a purchase made with the expectation of greater wealth in the future. This could be sowing improved germplasm, capital fertiliser or a land purchase (Gardner *et al.* 2005). In analysing the potential value of the capital investment, the investment decision should be separated from the financing decision (Davey & Vos 1993). The financing decision includes principle and interest repayments, taxation and cash flow. In the investment analysis, only cash items are considered, along with the taxation implications (Nuthall 2011). However, as taxation implications vary with the farm entity structure (company, partnership, trust, etc.), and are influenced by non-cash items (e.g., depreciation), for the purpose of this paper taxation is not included in the investment analysis.

The prospect of valuing the potential of a new on-farm investment brings with it many challenges. It can be daunting given a farm is a system that consists of a large number of interacting biological, economic, financial and social components. Further, each farm consists of a range of diverse resources (e.g. landscapes, animals, people and financial) that need to be included in the investment decision, but not necessarily simultaneously. Critically, most investments (e.g., capital fertiliser, new genetics, irrigation, forestry, etc.) are likely to impact differentially depending on which area of the farm they are applied to. These will result in changed feed demands and/or feed supply, the number and balance of stock classes through to such items as sale weights, number and dates, which will lead to a change in the farm system and its management. The decision to establish a block in forestry, plant a forage crop or change the selling policy from store to lamb finishing will all require changes in the farm system. Any one of these changes is also likely to lead to a change in capital livestock numbers and how each part of the farm is subsequently used and integrated into management of the farm as a whole. Whilst other changes, such as cash flow, and the need for the farmer and employees to develop new management skills, would also be necessary, they are not considered in this paper. The changes in cash flow would be captured in the funding analysis, when exploring if farm enterprise can fund the investment, given the investment is profitable and within acceptable risk parameters.

A number of farm systems models have been developed that can be used to analyse changes to components of the farm system. These are either a simulation approach as used by StockPol (Marshall *et al.* 1991), Farmax (www.farmax.co.nz) and Udder (www.udder4win.com), or an optimisation approach used by the Grazing Systems Model (Ridler *et al.* 2001), IDEA (Doole *et al.* 2013) and MIDAS (Kingwell 1987). As all these models operate at a whole farm level, it is very difficult to isolate, quantify and value the benefit of an investment made on just part of the farm (e.g. forestry, new grasses, forage crops, etc.) because it invariably results in changes in the stocking policy, land use and how the farm is managed. The approach taken in the farm systems model developed by Rendel *et al.* (2013) is to split the farm up into separate (near) contiguous areas (Land Management Units or LMUs) as part of the underlying model framework. In this configuration the model can optimise the contribution of all the LMU's, individually and collectively, across the whole farm to maximise profit. This allows investments made on part of the farm to be isolated, analysed and evaluated. Part of the model output is a picture of what the livestock policies on individual LMU's would be and hence how they have changed with the investment.

Invariably a capital investment analysis compares the new farm system with the old system. This is only valid if the new optimised system is compared with the original system which has also been optimised. To do otherwise, brings with it the danger of over- or under-estimating the value of on-farm investment.

In this paper we will take a sheep and beef farm with five LMUs and examine the impact on farm profitability of changing the use of the LMU with the lowest annual pasture production to exotic forestry by optimising the farm systems with and without an exotic forest block. The output of that analysis provides a basis for an investment analysis to determine how much the farm could afford to spend to establishing the forestry block. In the second analysis the value of a short-term investment in a multi-year forage crop to the whole business is established and then used to calculate how much the farm could afford to spend per hectare establishing the crop, based on the impact it has on the whole farm profitability.

Table 1 Area and annual pasture production of each LMU

LMU	Area (ha)	Estimated Pasture Grown (kg DM/ha/year)
1	208.7	12 133
2	178.6	9323
3	50.2	5733
4	89.8	7353
5	30.7	12 133
Total	558.0	9889

Materials and methods

The case farm is located north east of Whanganui, and has five LMUs totalling 558 ha (Table 1). Key dates, animal performance targets and costs are summarised in Table 2. More details are available in Rendel *et al.* (2013).

Two investment options are quantified. First a forestry option, where a block of land (LMU 3) was taken out of pasture production and planted in *Pinus radiata*, and the second, sowing a multi-year forage on LMU1.

Results

Forestry investment

The following analysis set out to establish what the 50.2 ha block (LMU 3) would need to earn from forestry over a 25 year planning horizon to be more profitable than under its current pastoral use.

INFORM was used to compare the farm system optimised with LMU3 in pasture and livestock farming, or when removed and planted in *Pinus radiata*. The two

Table 2 Key dates, animal performance and costs for the case farm.

		Beef Cattle	Sheep
Scan date		20 May	12 Jul
Scan Dry %		5	5
Scan % (foetuses / female pregnant)		100	168
Dry cull date		4 June	26 Jul
Median Parturition Date		30 Sep	16 Sep
Wean Date		12 Apr	16 Dec
Wean % (per female at parturition)		90	140
Wean Weight (kg)		240 (Bull), 230(Steer), 220(Heifer)	26 (average)
Cull Date		30 May	19 Feb
Mature female weight[1] at parturition		515 kg	57 kg
Replacement Rate %		22	22
Mature female annual cost[2]		$25	$25
Replacement female annual cost[2]		$17	$7
Finishing animal annual cost[2]		$17	$7
Death Rate	mature female	5% pa	5% pa
	replacements	5% pa	5% pa
	Finishing animals	5% pa	5% pa

[1] Conceptus-free live weight
[2] Annual per animal cost pertinent to that class (e.g., labour, animal health)

farm systems (Table 3) differ only in ewe and prime lamb numbers, as neither optimisation runs selected beef cattle as an option, as the sheep system was more profitable than the beef cattle options available.

Assuming that forestry has a 25 year period between planting and harvesting, and estimating the capital livestock required at start-up and their sale value at the end of the 25 year period, we compare the two farm systems over a 25 year investment horizon. The capital purchase, annual Earnings Before Interest, Taxes, Depreciation and Amortisation (EBITDA) and then sale of capital stock are discounted (5%) to form a Net Present Value (NPV) for the investment (Table 4). The discount rate will vary depending if inflation is included. If it is not, the best estimate is the risk-free rate for the period of the investment (see New Zealand Treasury http://www.treasury.govt.nz/publications/guidance/reporting/accounting/discountrates). The NPV can be converted to an annuity which is an equal sum of money received over each period of the investment (Malcolm *et al.* 2005). This makes the result less sensitive to the discount rate. That is the same discount rate is used in the NPV to bring future profit into the time period the investment is made, as to then convert that NPV into an annual repayment. Table 4 shows these flows and the resulting NPVs,

The difference in NPVs ($138 772) is the amount an investment on LMU3 would need to earn in order to break-even compared with the base farm system. The NPV from a forestry investment would need to yield a NPV of $2763/ha or provide an annual annuity of $196/ha/yr over the 25 year planning horizon. The farm owner would need to take into account risk and the costs of financing the investment as well as taxation before deciding to undertake the investment. Other, non-financial or intangible considerations would also

Table 3 Key details of the optimised Base farm system and that with LMU3 removed

	Base	LMU3 removed	Change
Area in pasture (ha)	558.0	507.8	-50.2
Ewes (30 June)	5237	5020	-217
Lambs sold prime	5554	5319	-236
Replacement Ewes (30 June)	1200	1150	-50
Nitrogen Applied (kg N)			
8 April	271	1435	1164
9 Sept	6610	6 091	-519
EBITDA[1]	$378 675	$366 971	-$11 704

[1]Earnings before Interest, Taxes, Depreciation and Amortisation

Table 4 Investment analysis for each of the two scenarios assuming a discount rate of 5%.

	Base	LMU3 removed	Change
Livestock Purchase	-$898 904	-$861 753	-$37 151
Year 1	$378 675	$366 971	-$11 704
Year 2	$378 675	$366 971	-$11 704
⁞	⁞	⁞	⁞
Year 25	$378 675	$366 971	-$11 704
Year 25 Livestock Sale	$898 904	$861 753	-$37 151
NPV	$4 703 568	$4 564 796	-$138 772
Annuity	$333 730	$323 883	-$9 847

Table 5 Characteristics of pasture and forage crop used in LMU1(GRs is pasture or forage growth rate, kg DM/ha/day; Energy is MJME/kgDM).

	Pasture			Forage Crop		
Period	GRs	Energy	Utilisation %	GRs	Energy	Utilisation %
Jan	54	10.8	80	65	11.8	85
Feb	45	10.5	80	54	11.5	85
Mar	35	10.8	80	41	11.8	85
Apr	26	10.8	80	31	11.8	85
May	20	10.8	82	24	11.8	87
Jun	11	10.8	85	11	11.8	90
Jul	10	10.8	85	10	11.8	90
Aug	16	11.0	83	16	12.0	88
Sep	26	11.2	81	31	12.2	86
Oct	40	11.3	80	48	12.3	85
Nov	54	11.1	80	65	12.1	85
Dec	64	11.0	80	77	12.0	85

be in the mix (e.g., farm management becomes easier or more difficult, natural resource protection, increasing biodiversity, risk of wild fire and wind-throw, cash flow, etc.).

Forage crop investment

Assuming that LMU3 is in forestry, what would be the value of planting a multi-year forage crop on LMU1, and more specifically, how much of the 209 ha should be planted to maximise farm profit? For this exercise the multi-year forage crop has faster growth rates (18% more fodder grown annually), except during winter, greater energy content (+1 MJME/kg DM) and higher utilisation by grazing animals (+5%), than the resident pasture found on LMU1 (Table 5). It requires an additional $424/ha/yr to maintain the forage crop (fertiliser, nitrogen, weed control, etc.) compared with pasture ($213/ha/yr).

When given the option the farm optimisation model (INFORM) chose to put all 209 ha of LMU1 in forage crop resulting in a new livestock policy (Table 6). This increased EBITDA by $23 910, but required the purchase of additional capital stock. To establish how much a farmer can afford to pay for this investment, the breakeven point compared with the existing system, assuming either a 3 or 5 year forage crop life, needs to be determined.

Using the same approach described above for the forestry investment, the NPV's can be calculated (Table 7). To break even only $171/ha and $271/ha could be spent on establishing the forage crop if the crop lasted for 3 and 5 years, respectively,

Table 6 Key details of the optimised farm system with LMU3 removed (Base for this analysis) and with the option of a multi-year forage crop

	Base (LMU3 removed)	Forage Crop	Change
Farm area (ha)	507.8	507.8	
Area LMU1 pasture (ha)	209	0	-209
Area LMU1 forage crop (ha)	0	209	209
Ewes (30 June)	5020	6282	1262
Lambs sold prime	5319	6669	1350
Replacement Ewes (30 June)	1150	1439	289
Nitrogen Applied (kg N)			
8 April	1435		-1435
20 May		1219	1219
15 July		1219	1219
9 Sept	6091	1219	-4872
EBITDA[1]	$366 971	$390 882	$23 911

[1]Earnings before Interest, Taxes, Depreciation and Amortisation

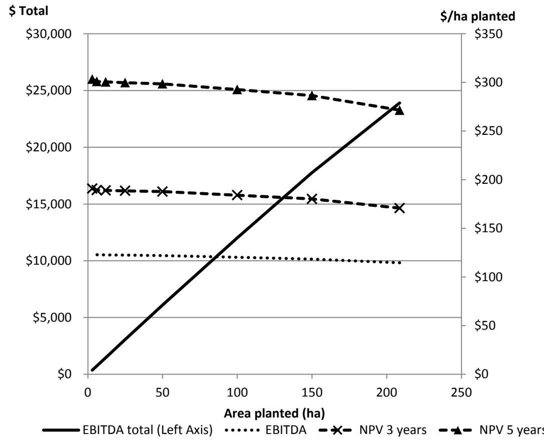

Figure 1 The difference from Base of EBITDA (solid line), EBITDA/ha planted (dotted line) and NPV/ha planted for a 3 year (dashed cross line) and 5 year (dashed triangle line) life of the forage crop.

An interesting question to explore is the investment implications of constraining the portion of LMU1 that was sown into a forage crop. This was modelled by forcing in 1, 3, 6, 12, 25, 50 or 100 ha of forage crop into LMU1, with the balance remaining in pasture. As more of LMU1 is planted in the forage crop, EBITDA over and above base increased almost linearly (Figure 1 solid line). The difference from base in EBITDA/ha planted decreases slightly (dotted line). However the difference in NPV/ha from base, for both a 3 and 5 year life of the crop (dashed line) decreases noticeably with increasing area planted.

Discussion

To look at investments on farm, all capital requirements, including the change in livestock numbers, need to be accounted for. The first case study shows that the forestry investment would need to earn $2763/ha over the 25 year planning horizon, an annuity of $196/ha/yr, to break even with the farm system with LMU 3 remaining in pasture. The second case study showed increasing profit from the planting of a forage crop, albeit the marginal return for each additional hectare planted decreases slightly.

Table 7 Net Present Values for a 3 year and a 5 year forage crop.

NPV	LMU3 removed	Forage Crop
3 year life	$882 015	$917 647
Difference /ha planted		$171
5 year life	$1 402 246	$1 458 894
Difference /ha planted		$271

What both investment analyses show is how much an investment needs to earn to replace an existing enterprise on the farm and how much can be spent to make a worthwhile investment. These are made possible by the fact the farm systems model of Rendel *et al.* (2013) configures the farm to realise the full potential of an investment to the whole farm, and at the same time is able to isolate the value of the investment to the whole business.

Often an investment is compared directly with the current situation. However, for a valid comparison, where the new investment scenario is optimised it needs to be compared with an optimised current situation. The assumptions or methodology needs to be applied to both. For example, if you optimise the investment scenario, you need to optimise the current situation otherwise the methodology – optimisation – gets confounded with the investment decision. Also the same costs and prices need to be used, which may not be as easy as it appears.

Further, an on-farm investment often requires a change in the farm system in order for the benefit to be captured. For example an increase in lambing percent will result in an increase in ewe feed requirements over pregnancy and lactation, compared with the base situation. This will flow through to more lambs per ewe at weaning and will require a rethink of the livestock sales policies. Recognising these changes along with how different areas of the farm are best utilised is an additional consideration. Including all the changes to the farm systems is likely to add substantially to the value of the analysis, especially when linked to the change in capital livestock numbers. The use of farm system optimisation models allows that re-design of the farm system to be undertaken in an objective and consistent way.

The investment analysis is not the end result, merely one of the steps. There are several elements missing from this analysis. Firstly risk, both from a climatic angle (which will influence pasture growth rates and sale prices) and a sale price perspective, is not considered. If the crop growth is very highly positively correlated with pasture production then this is probably not an issue. However if not, then this could have a large influence. This could be addressed in a number of ways (e.g. multi-year models, real options analysis). Secondly, taxation implications are not included, which would need to be for a robust analysis for a business considering the investment.

Another issue is how the investment is funded. This may require the farm enterprise borrowing money, or could it be done out of reserves. These options will likely more impact on the financial resilience of the farm.

And one also needs to take into consideration the aspirations, goals and motivation of the farmer. There may be changes that are not profitable, but allow the farm system to operate more smoothly, or labour and management inputs could be changed, which could be worthwhile.

Summary

We have shown that it is important to consider all the capital and management requirements when undertaking farm analysis that involves a farm system in which animal numbers change as a result of a potential investment and the investment has a planning horizon. This is made possible by INFORM which enables as part of the analysis both the base or current system and the new system to be treated similarly (e.g., both are optimised). The approach outlined can be used to both value a technology as an investment, or estimate how much could be invested in a technology given the expected performance levels. From an industry perspective, an EBITDA approach is suitable. However an individual farmer or company would need to consider taxation, as well as options for funding the investment, and any intangible elements and personal goals.

The extremely important factors of risk and uncertainty have not been considered in this paper. However these issues are at the forefront of the authors' thinking.

ACKNOWLEDGEMENTS

Dougal & Di MacIntosh for allowing us to use their farm and for the many interesting discussions that we have had. Rob Jackson for introducing John to the world of finance and economics, and encouraging the study of Operations Research. Tony Rhodes as a reviewer for insightful comments on the manuscript.

The authors would like to acknowledge the Pasture 21 Consortium for funding the development of the sheep, beef and dairy grazing component of INFORM. Further, DEEResearch for funding the addition of the deer venison sub-model.

REFERENCES

Davey, H.; Vos, E. 1993. Financial management and decision making: a user-oriented approach for the business manager. 3rd edition. Butterworth, Wellington, New Zealand.

Doole, G.J.; Romera, A.J.; Adler, A.A. 2013. An optimization model of a New Zealand dairy farm. *Journal of Dairy Science 96*: 2147-2160.

Gardner, J.; Nartea, G.; Shadbolt, N. 2005. New opportunities: investments in farming. pp. 221-266. *In*: Farm management in New Zealand. Eds. Shadbolt, N.; Martin, S. Oxford University Press, Australia.

Kingwell, R.S. 1987. A detailed description of MIDAS. *In*: MIDAS, a bioeconomic model of a dryland farm system. Eds. Kingwell, R. S.; Pannell, D. J. Pudoc, Wageningen.

Malcolm, L.R.; Makeham, J.P.; Wright, V. 2005. The farming game: agricultural management and marketing. 2nd edition. Cambridge University Press, Melbourne, Australia.

Marshall, P.R.; McCall, D.G.; Johns, K.L. 1991. StockPol: A decision support model for livestock farms. *Proceedings of the New Zealand Grassland Association 53*: 137-140.

Nuthall, P.L. 2011. Farm business management: analysis of farming systems. CABI, Wallingford, UK.

Rendel, J.M.; Mackay, A.D.; Manderson, A; O'Neill, K. 2013. Optimising farm resource allocation to maximise profit using a new generation integrated whole farm planning model. *Proceedings of the New Zealand Grassland Association 75*: 85-90.

Ridler, B.J.; Rendel, J.M.; Baker, A. 2001 Driving innovation: Application of linear programming to improving farm systems. *Proceedings of the New Zealand Grassland Association 63*: 295-298.