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SOME ISSUES OF RISK ANALYSIS AT THE FARM LEVEL

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This paper reviews recent applications of corporate finance analysis to the farm firm. These include use of optimal capital structure theories to elucidate investment strategies, including tax shelters, and capital asset pricing models(CAPM) to elucidate portfolio choices both on and off farm. Risk management issues concern the appropriate place of risk premiums in investment decisions, the separation of business and financial risk, the influence of tax rebates on interest on capital value, the reduction of risk through diversification, and optimal farm plans that are risk efficient. The common factor in this approach is the key role of business risk in setting both risk premiums for investment and in the minimisation of diversifiable risk for risk efficiency. Further, project selection in the diversification situation can be made risk efficient. The CAPM can also be fed into the estimate of the weighted cost of capital. The paper concludes with a discussion of option pricing and arbitrage pricing and how these might be utilised to analyse the farm firm decision process.

THE OPTIMAL CAPITAL STRUCTURE

The corporate finance view of optimum capital structures has been highly influenced by the work of Modigliani and Miller(1958) (MM henceforth). The cost of capital is viewed as the weighted average of debt cost and required equity return(WACC). Required equity return incorporates business and financial risk premiums as in Diagram I. Business risk is defined as operating risk arising out of the ordinary operations of the firm and financial risk as additional risk taken on by external borrowing(leverage). The MM proposition is that the WACC is invariant to the level of leverage and there is no optimal level of the debt-equity ratio.

They pointed out that in corporate financial structures any increase in the use of "cheaper" debt funds is offset by the increase in the equity capitalisation rate. Investors are hypothesised to penalise the price of stock by raising the equity capitalisation rate (lowering the price/earnings ratio) directly in keeping with the debt-to-equity ratio. MM hypothesised and advanced considerable behavioural evidence for arbitraging of stock in such a way that the average cost of capital would remain unchanged as debt-equity ratios changed.

In considering farm firms the conditions assumed by MM no longer apply. The structure of equity held by proprietors means that there is not an efficient market for equity where

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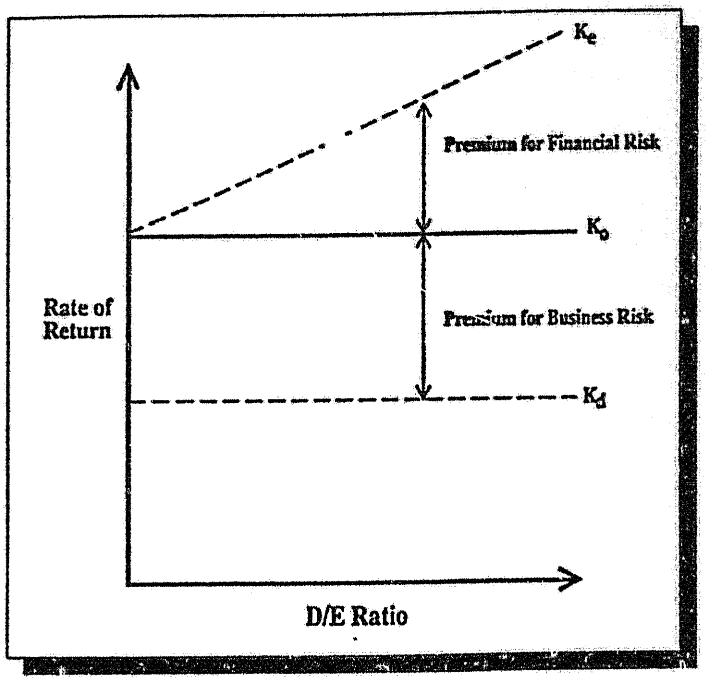
DIAGRAM I

Derivation of Premium for Financial Risk



the equity capitalisation rate can freely compensate for increased debt (Collins, 1985, p 627). In this case it is hypothesised that the proprietor's views on financial risk will determine the shape of the Ke curve , and that the average cost of capital will vary according to the behaviour and weighting of the required return on equity of the proprietor and the cost of borrowing.

This situation - called the traditional approach in the literature (Van Horne, 1983, p 249)(Hawkins and Pearce, 1971, p 58) - suggests that the average cost of capital will at first fall with increased leverage and later rise again as the financial risk dominates the situation (Diagram 2). It is generally agreed that that the cost of borrowing to the farm firm is likely to increase with increased leverage after a point. Also financial risk is seen as an increasing function of leverage. In this case, therefore, there is a gain to the proprietor in moving towards some middle position of debt and equity mix. This is the standard position described in the agricultural finance texts (eg Penson and Lins, 1980, p 188).

The minimum point on the Ko curve represents the least cost combination of the sources of capital finance. It also represents a stable capital structure which may be disrupted from time to time when financing new investment projects.

The increasing function of required equity return with increasing leverage is associated in the literature with an increasing probability of bankruptcy (Van Horne, p 262) and with distress costs (Bishop, Crapp and Twite, 1988, p 138). Distress cost occur when a firm's cash flow falls below expectations. Costs are incurred in modifying investment and finance strategies. Foregone investments may incurr significant opportunity costs. Bankruptcy is a form of extreme distress and involves many costs a firm would wish to avoid (Pringle and Harris, 1987, p 498). A reason for increasing debt cost with increased leverage at the limit is increased agency or monitoring costs (Van Horne, p 272).

As the debt-equity position of the firm increases, debt-holders would wish to cover the increased cost of monitoring the firm's performance and behaviour. All these risk factors tend to lift the perceived cost of increasing debt in a firm and reduce the optimum debt-equity ratio at which it is prudent to operate.

It is therefore possible to argue that in a risk-averse world there are justifiable limits to the process of seeking higher and higher debt-equity ratios in order to reduce the average cost of capital. In a risk-free environment, increased debt reduces the average cost continuously. In a risk-averse environment, prudent limits need to be determined, dependant upon the threat or probability that changes in both business risk and financial risk could affect the continuation of the business. Changes in debt costs are likely to be market determined and closely measurable; changes in equity returns are more psychological and can only be interpreted from the behaviour of proprietors of business themselves, or the stockholders, as the case might be.

The CAPM offers some insight into the measurement of the required return on equity and is discussed below. Further thought needs to be given to a utility function approach incorporating some idea of the degree of risk aversion. There could be some connection between the proprietor's mean-variance trade-off and his required rate of equity return.

Tax Shields

Modigliani and Miller subsequently modified their position on invariate average cost of capital. The fact that corporate tax legislation allows firms to deduct interest on debt alters the effects of leverage on the firm. This gain to the firm, or loss to the government revenue, is the tax shield. An increase in leverage decreases the share of of pre-tax operating profit going to the government and increases the share going to debt and equity (Pringle and Harris, p 494). The firm's cash flow to owners increases with leverage because of the tax exemption provided by debt.

MM developed this proposition in terms of the effect on a firm's value. Without leverage, a firm's value is defined as the present value of the future cash flow stream to investors. With borrowing, the cash flow is increased by the value of the annual tax shield of interest. Therefore the value of the levered firm is equal to the sum of the two streams in present value terms.

The question then arises as to what constraints there are on unlimited exploitation of tax shields. Van Horne (1983, p 272) suggests a modified value relationship where tax costs, bankruptcy, and distress costs and agency costs all combine to reduce the size of the tax reduction benefit as leverage increases. As Myers (1986) says, a firm's optimal debt ratio can be viewed as being determined by a trade-off of the costs and benefits of borrowing, holding the firm's assets and investment plans constant. The firm can be portrayed as balancing the value of interest tax shields against various costs of bankruptcy or financial embarrassment.

In this case, depending on the nature and size of these costs, an optimal value structure may occur at quite low debt-equity ratios. As Pringle and Harris stress (1987, p 499), as leverage increases, the firm reaches a point where the expected costs of financial stress and reduced flexibility begin to outweigh the benefits of the tax subsidy. They point out that in the actual event of bankruptcy, tax credits from interest cannot be recovered from the government unless the firm merges with another firm or manages to carry its tax credits forward in some way. Also tax credits can only be generated if the firm is making profits - otherwise there is nothing to claim against.

The effect of the tax shield is the same for the weighted average cost of capital. Since a proportion of the interest cost of debt is tax deductible, the actual cost to the firm is less as long as the firm is making profits. Bishop, Crapp and Twite (1988, p 313) point out that the WACC must fall substantially if the tax deducted cost of debt is included (Diagram 3). This incorporates the 1963 MM position that an invariant WACC must be transformed to a downward sloping average cost function as leverage increases (Ko).

Bishop et al then raise the question whether such a downward slope is continuous? "We do not observe all-debt financing; hence we need to introduce further capital market imperfections into our analysis to explain observed capital structures". They thus re-introduce distress costs to the argument including it in both the debt side and the equity side (Diagram 4). There is an increased probability that debt holders will not receive interest/principal payments as leverage increases as shown by Kd. This transfers the burden of distress costs to the equity holders, and the valuation of equity falls (the authors assume the MM conditions still prevail). The required return of equity holders also increases. These conditions determine that the firm's optimum rate of return will be u-shaped and not monotonic. At the optimum the tax advantage from leverage is equal to the expected loss from distress costs.

The authors maintain that the compensatory mechanism between debt return and equity return operates in the corporate world, even though average cost is no longer invariant. For the farm firm proprietor shown in Diagram 2 the effects of the tax shield are similiar. This is shown in Diagram 5. Here the equity owner becomes highly risk averse as his debt-equity ratio rises. He benefits from low post-tax interest costs as long as he makes profits. After a point debt-holders only lend to him at greatly increased premiums, hence the average cost of capital at first falls moderately as he takes advantage of the low-cost borrowed capital, but then the cost rises again as his required risk-averse equity return is increasing rapidly.

At the end of the day, the "traditional" approach and the MM approach appear to produce very similiar results for the tax shield, risk-averse situation. However it is important not to over-emphasise the role of the tax shield. Myers (1987, p 94) points out that there are other ways to shield income. Firms might have accelerated write-offs for plant and equipment, investment tax credits, research and other intangible assets, and even contributions to a pension fund. These shields serve to dilute the effect of of the interest shield alone and they reduce its certainty. As Van Horne points out (p 256) the greater the tax sheltered income of a company the less important the tax shield on debt in an uncertain world.

An Evaluation

McCrea, Grundy and Hay (1990) report an evaluation of tax shields in agriculture using a representative farm. They use

DIAGRAM II

The Traditional Approach to Weighted Cost of Capital

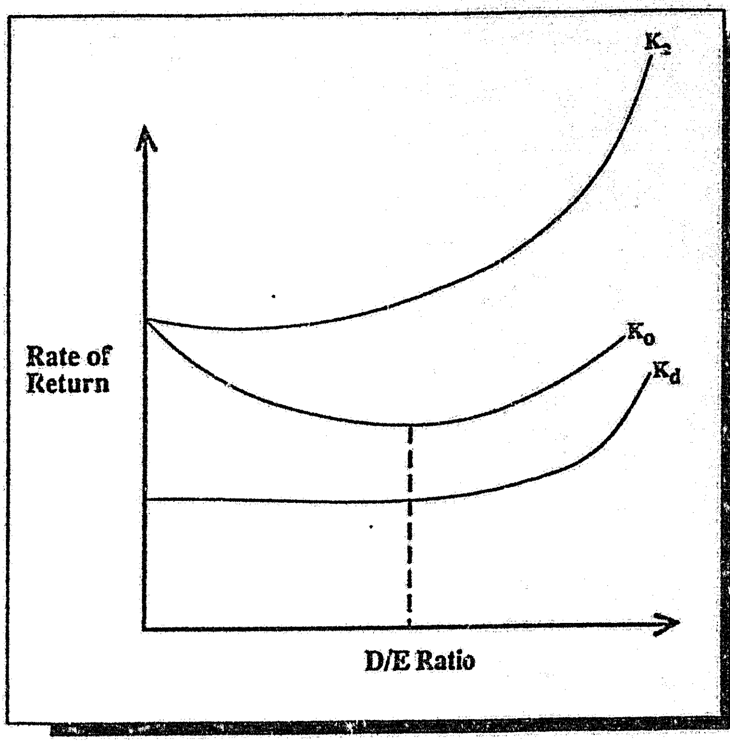
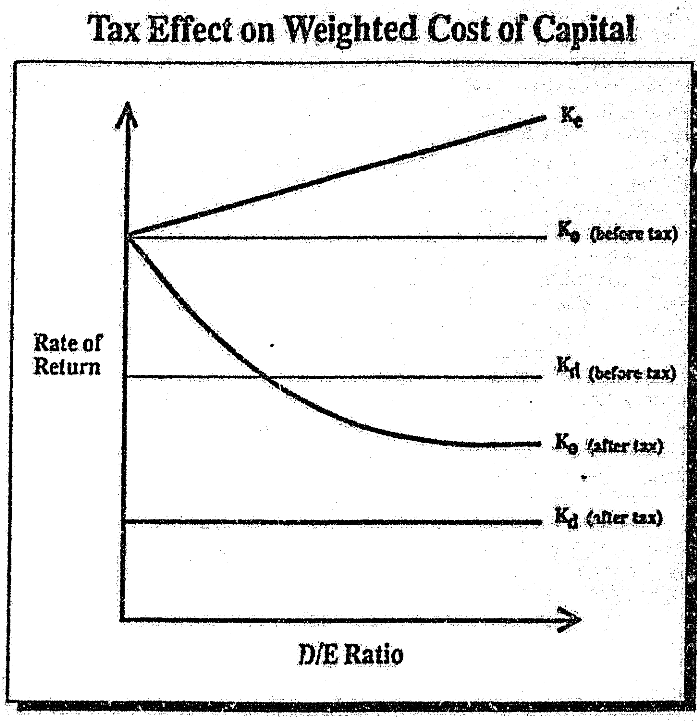


DIAGRAM 3



Tax Effect on Weighted Cost of Capital
Rate of Return
D/E Ratio

DIAGRAM 4

Tax Effect with Distress Costs

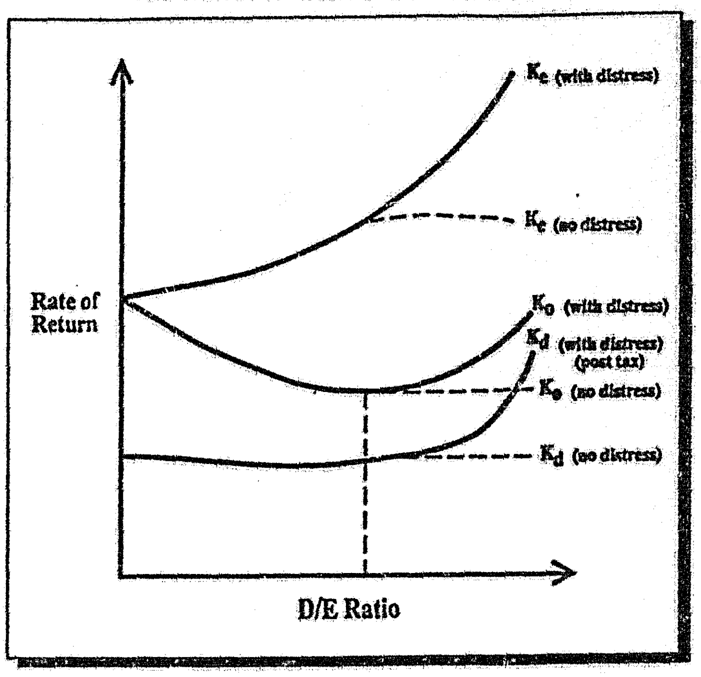
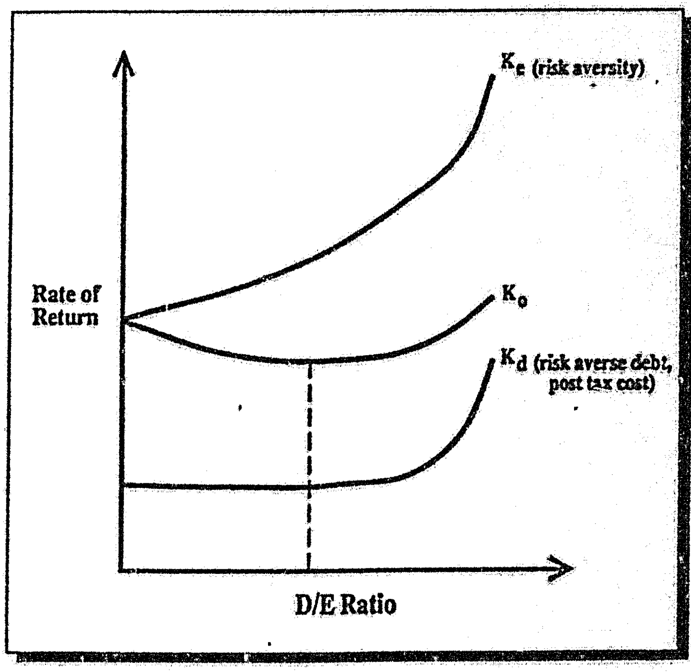


DIAGRAM 5

Tax Effect and Agricultural Proprietor



the @RISK software to generate with and without development budgets and cash flows to evaluate the "value" impact of the tax deductibility provisions in New Zealand (See Diagram 6a).

The farm firm is based on a Canterbury sheep breeding property of 350 ha and 3000 sheep stock units. In 1989 the asset value of such a property was $634000 made up of $197000 debt and $437000 equity. The without hypothesis is steady sheep breeding and the with hypothesis is the introduction of deer and beef enterprises. These are then evaluated with current tax provisions and 1984 tax provisions which were somewhat more generous. Both with and without are subject to the same set of tax provisions. Major interest was placed on the interest deduction but other shields were investigated as well.

@RISK is a simulation package which enables probability distributions to be specified and random values drawn as required. Also variances between distributions can be incorporated in the final outcome. @RISK output includes cash flows and net present values. Key results include the mean, standard deviation, and probability <0 for NPV for each scenario.

Diagram 6 shows the main cash flow effect of a tax shield in a development/diversification situation and Table I shows the corresponding cash flows and marginal present values. The figure shows the total annual values of the interest tax shield in an investment situation involving diversification to deer. Full deductibility is compared with nil deductibility for the property as a whole. The marginal NPV is the extra tax shield effect due to the new financing situation associated with the deer diversification. In addition the table explores the effect of setting the interest deduction in real terms rather than in nominal terms.

The present values of the tax shield in Diagram 6 are $44009 for current tax rates and $69117 for the old tax rates. At the margin these reduce to $22141 with 100% deduction of interest and $18891 with nil interest deduction. Thus the marginal gain in "value" is $3250 from taking on increased debt.

The authors only provide some of the results affecting changes in the financial concept of value. These are:

(i)	fast deer development-current taxes	+$3250
(ii)	fast deer development-real interest,current	+ $180
(iii)	fast deer development-old taxes	+$9509
(iv)	fast deer development-real interest,old	+$4462
(v)	slow deer development-current taxes	+$1562
(vi)	slow deer development-old taxes	+$4526

The "value" equation is set out as follows following Diagram 6b:

DIAGRAM 6a

Value to the Firm of the Tax Shield

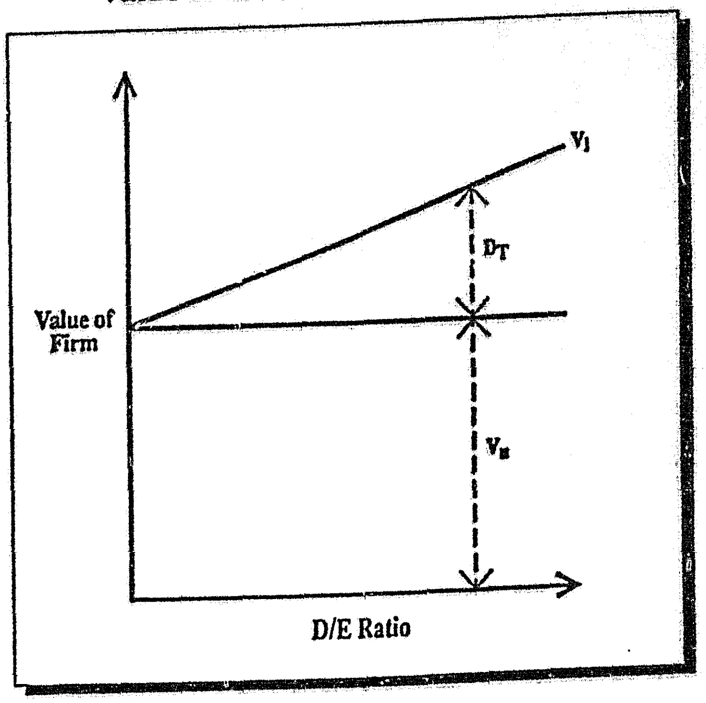


DIAGRAM 6b

Effect of Distress Costs on Value of the Firm

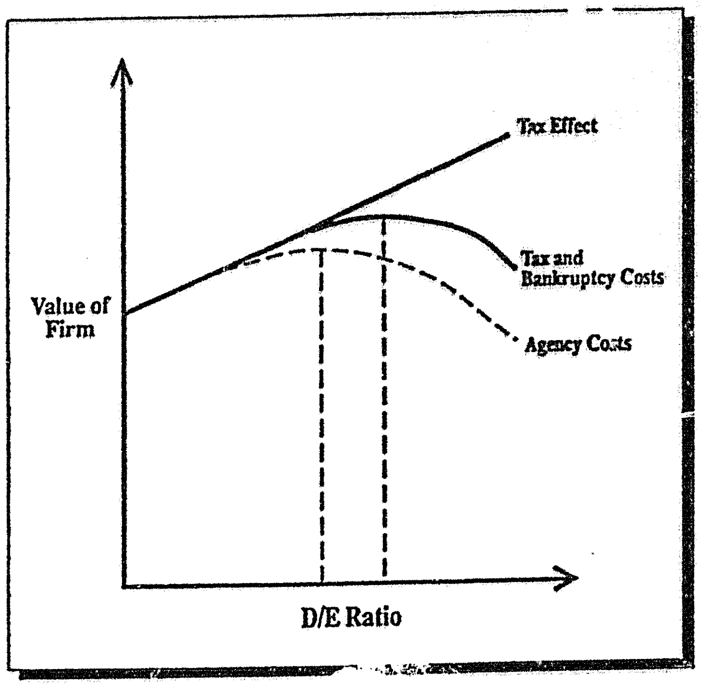


DIAGRAM 6

VALUE OF 100% INTEREST DEDUCTIBILITY TAX SHIELD
(after McCrea et al, 1990).

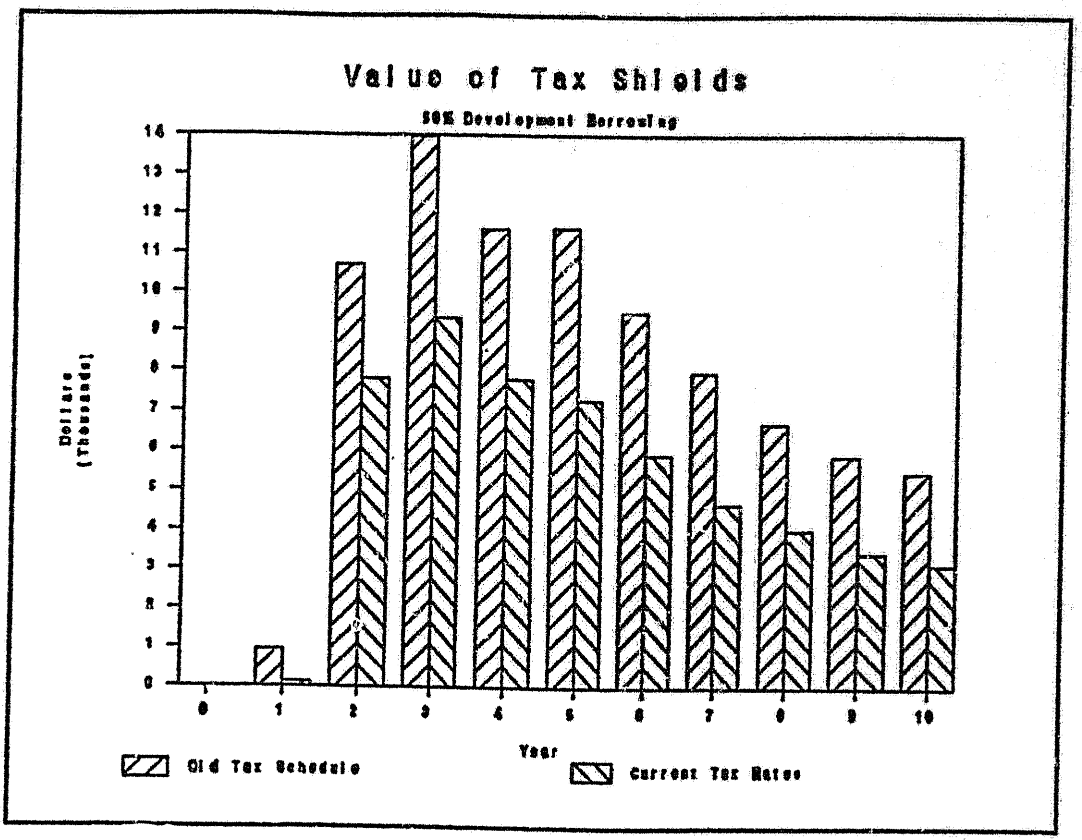


TABLE I

PRESENT VALUE OF INTEREST TAX SHIELD DEDUCTIONS
(after McCrea et al, 1990).

Cashflows and Probabilities of Loss for Fast Deer Development
(Present Tax Rates)

% Interest Deductible:	100%		REAL		0%	
YEAR	NCF ($)	P(NCF<0) %	NCF ($)	P(NCF<0) %	NCF ($)	P(NCF<0) %
0	-91949	100	-92117	100	-91949	100
1	10987	29	11363	29	10867	27
2	20573	12	19465	7	12765	14
3	19985	11	17905	18	10623	27
4	19344	15	16388	16	11527	25
5	29230	4	27112	4	21957	10
6	29212	3	28726	4	23313	7
7	30927	4	29667	2	26263	5
8	32476	2	31364	2	28443	4
9	33607	3	32588	5	30162	4
10	130936	0	128269	0	127799	0
Marginal NPV	22141	27	19071	31	18891	31

Note: Fast Deer Development, $130,000 Mortgage, 50% Development Borrowing, Present Tax Schedule

NPV shown is not NPV of cashflows in table, but of marginal increment from with development over without development

Value of = Value if + Value of - Value lost
of firm unlevered non-interest through non interest
tax shields tax shield uncertainty

\+ Value of interest - Value lost
tax shield through interest tax
shield uncertainty

The above results thus explore the linear values of the tax shields and the uncertainty factors must be interpreted through the variance measure. In Table 1 the probability of a negative NPV decreases with full interest deduction. This suggests that the downside risks of development are slightly reduced by full deductibility. This is also reflected in the coefficient of variation about the mean NPV of 187% for full interest deduction and 209% for nil interest deduction. Thus variability in the cash flows is reduced in this case and little further can be deduced about the ultimate threat from over-borrowing.

The magnitude of the marginal value of the tax shield can also be judged against the unlevered value of the farm firm. These present values are like stumpage values and can be directly added to capital value. Thus $9509 under the old tax provisions is some 1.5% of the farm value of $634000(assuming that this is roughly equivalent to the present value of the future stream of net return to all capital), and the other results scale under this. Again this establishes that the gains from tax shields are positive under the assumptions made but adds very little to uncertainty and to the theory of optimum capital structures which it was originally meant to elucidate (see Myers, p 101).

This approach is fruitful. It should be explored further. In particular, the diversification hypothesis should be linked to the reduction of over-all risk in the firm. With CAPM diversifiable risk could be isolated and tested. The dis-utility of greater borrowing could be explored. The limits to borrowing may well be found in future profitability of new investments and lender's restrictions rather than in tax breaks and the optimal capital structure. This research is a splendid start in the right direction.

Other Results

Other scenarios examined by McCrea et al do not involve the debt-equity ratio. These include two different systems of valuing livestock, farm development allowances, spreading provisions, the old and new tax regimes(already referred to), and different loan rates. With constant prices there is little difference between the "herd scheme" and the "trading scheme" valuation methods, but if price levels are rising there is a greater shelter derived from the herd scheme. Both the former development allowance and the spreading provisions have sizable net benefits in the with and without situation and the spreading provisions were decididly more generous under the old tax provisions. A straight comparision of the old and new regimes show a net benefit to the new system. In this case higher deductions were more than cancelled out by higher marginal tax rates. The results for different borrowing rates of interest show considerable sensitivity to discount rates and a large tax shield "value" can be created by use of post-tax mortgage borrowing rates.

DISCOUNT RATES V CAPITALISATION RATES

To determine the appropriate " value" of a farm firm information is needed on the correct discount rate in cash flow models and on the capitalisation rate in a one-year situation. If E is equity and D is debt and V is farm value, then

$$V = D + E$$

$$\text{and WACC(Ko)} = \frac{D}{V} Kd + \frac{E}{V} Ke$$

Now WACC is normally the appropriate rate of return to capitalise net income to determine farm value, V. It is clearly made up of two separate rates of return, the actual pre-tax cost of borrowed capital (which might incorporate a small risk premium set by debt-holders) and the required pre-tax risk-averse rate of return on equity. It would not make sense to capitalise the net return to equity at the equity capitalisation rate as this avoids placing a value on debt.

In the case of the proprietor who wishes to invest in new directions (like diversification or development) he will need to evaluate the present value of each investment option. In this case the appropriate discount rate will be the required equity capitalisation rate and not the WACC. If the proprietor accepted a discount rate below Ke he would be accepting an investment prospect which did not maintain or improve his existing level of desired equity income, ie he would be worse off. Furthermore his margin for business risk would not be covered. It follows that neither the outside borrowing rate nor the WACC are appropriate for investment evaluation. Bishop et al express this as earning a rate or using an opportunity cost equivalent to the best alternative of equivalent risk.

Such an adjustment for risk in the discount rate runs counter to public sector investment criteria where risk factors are normally incorporated in the cash flows and discounting is at some risk-free rate. A higher risk-adjusted discount rate would put more emphasis on short and medium term projects and preclude longer-term projects. This approach does seem more appropriate in economic times when government intervention has diminished and the farm sector faces floating exchange rates. Low capitalisation rates encouraged by government policies lead to high prices for the land asset and financial over-exposure of farm firm proprietors. Risk has been under-estimated in the past and caution stilled in the heat of commodity booms and/or misconceived government programmes. This applies to both wishful farm asset investors and to financial intermediaries who should know better. An alternative treatment of investment and discounting is option price theory (OPT) discussed below.

An estimate of Ke can be obtained by utilising the CAPM (Shim and Siegel,1986,p 249). The risk-adjusted cost of equity is defined as:

$$Ke = Rf + B\ (Rm - Rf)$$

where

(Rm - Rf) = average equity risk premium of some portfolio over a risk-free rate such as Rf,
B = beta or relative risk of the investment in question.

CAPM thus treats business risk and financial risk together and estimates one margin for all relevant investments compared with a risk-free rate and another margin for the particular systematic risk associated with a single investment. This formulation accepts systematic risk as a proxy for total risk. If B ranks projects in the same way as some criteria of total risk then either method could be accepted. As discussed below for the diversification problem these rankings may not always be the same.

Should farm firms use a pre or a post-tax rate of return for discounting? It was previously argued that the appropriate farm model was in pre-tax terms on the grounds that the farm was a trading entity and tax was the responsibility of the proprietor. Corporate practice appears to be the opposite of this. Such information tells them what returns on a dividend basis can be expected from an investment. This does not seem appropriate for the farm proprietor even though he could and should use all the tax shelters available.

Anderson (1990) reports an evaluation of farm land values in New Zealand which uses an after-tax model of capitalisation rates. He argues that the effects of both tax deductibility of interest payments and debt erosion reduce the investor's effective required rate of return and that the capitalised value of farmland for a purchaser who uses debt finance is subsequently greater than that calculated for an all equity investment. His best results derive from data for debt/asset ratios based on the maximum level of debt that the New Zealand Rural Banking and Finance Corporation will allow a mortgagee to borrow measured as a percentage of total farm asset value. He therefore concludes that the marginal land purchaser does use a relatively high level of debt finance to take advantage of its potential benefits (Anderson, p 107).

Given this evidence of tax shields influencing the farm purchasing decision, the market for land is not independant of tax structures. It therefore seems likely that marginal investment decisions on farm should also be judged from this point of view and post-tax versions of WACC employed. More analysis is needed on this point.

ENTERPRISE SELECTION AND THE CAPM

The application of the capital asset pricing model (CAPM) to share portfolio selection arose out of the search for simpler procedures than the Markowitz quadratic programming approach (Sharpe,1963; Lintner,1965). A saving in data manipulation was achieved but solutions still had to be approached through quadratic programming (Elton and Gruber, 1987). CAPM depends on identifying an (almost) risk free portfolio to act as a reference point. Risk of an investment is related to the variability of that investment return in relation to the reference set. This was measured by the B coefficient of the regression of the share return on the portfolio set. Thus was B born.

$$Ri = ai + B(Rm) + Ei$$

where Ri = rate of return on a single share

Rm = average return on a well-diversified portfolio of shares

and Ei = error term.

More recently, the same reasoning has been applied to the farm diversification problem (Collins and Barry, 1986; Turvey and Driver, 1987; Turvey, Driver and Baker, 1988). "The objectives are to develop risk measures, based on single index parameters and computationally simple methods for farm risk planning, that are suitable for micro-computers and modern hand-held calculators. The intent is to produce a normative model with possible extension applications"(Collins and Barry, summary).

In this case Ri becomes the net rate of return on enterprise i; Rm is the average rate of return on a "portfolio" of enterprises and B measures the amplitude of common fluctuations in the returns to the single enterprise in relation to the average. The coefficient ai can be interpreted as the expected return on the asset when the market return is zero. Estimates of these values can be obtained from time series data.

The take-off point for this analysis can be traced back to the definition of business risk used earlier. Business risk was defined as operating risk arising out of uncertainty about the future profitability of the firm independent of leverage.
In the finance setting, emphasis falls on market risk which is defined as economy wide perils which are likely to threaten all businesses, such as changes in the money supply, interest rates, the exchange rate, prices of commodities, government spending and the performance of overseas economies (Narayan, 1990, p 49). That proportion of the fluctuations in a single enterprise or activity that is common to market risk is called systematic risk and the residual variation non-systematic risk.

Alternatively the residual variation can be thought of as diversifiable risk. Manipulation of the diversifiable risks of the portfolio of enterprises will produce a least risk mix of enterprises. By definition systematic risk cannot influence the internal diversification decision (see Diagram 7). Now quadratic programming resolves the enterprise choice problem in terms of total risk taking account of the covariances between the returns from the enterprises. The adaption of the CAPM allows focus on the variances and covariances of the systematic and non-systematic risks of enterprise choices.

The question then is: do these distinctions allow Collins and Barry's objective of simple farm risk planning to be achieved?

Collins and Barry(1986) take a spread of Imperial Valley crops and compare a QP approach to a CAPM approach. Because B is used as a substitute for the variance-covariance matrix the CAPM approach is called the single index method. They demonstrate that the contribution to the income variability of a well-diversified firm by a particular activity is proportional to its B coefficient. They suggest that single index measures computed from historic data could have higher forecasting accuracy than use of the full variance-covariance matrix to represent future risk measures. It could also overcome the high degree of collinearity often found among risk-programming activities with a full covariance model.

They then compare the full method with the abreviated method in a QP framework. Diagram 8 shows their graphs of the Markowitz E-V frontier and the Sharpe E-V frontier. They comment that the single index frontier ought to lie inside the M frontier and that the level of accuracy in the single index method appears comparable to those achieved in other studies of stock portfolios. Considerable savings in computor time are achieved.

Turvey and Driver(1987) present empirical estimates of enterprise B coefficients and relate them to gross revenues of Ontario crop and livestock enterprises. They do not present QP results but concentrate on the array of B's and the division of total variance between systematic and non-systematic risk. The r measure of systematic risk is based on the ratio of r to 1-r which is hard to follow as it does not reflect the ratio of the variance explained and unexplained. They use current prices rather than deflated revenues as in Collins and Barry. Their results add to those of Collins and Barry in identifying the sensitivity of the above measures to different definitions of revenue and portfolios. Further research into holdings of non-farm assets and extension applications of the single index model are strongly urged.

Turvey, Driver and Baker (1988) return to the QP problem on a case farm of a combined cash-crop, beef feed-lot operation in southern Ontario. Systematic risk is now defined as r squared and non-systematic risk as 1-r squared. The results for the single index model are similiar to the full variance-covariance model. They include an LP which minimises B. They

DIAGRAM 7

GAINS FROM DIVERSIFICATION
(after Rao, 1987).

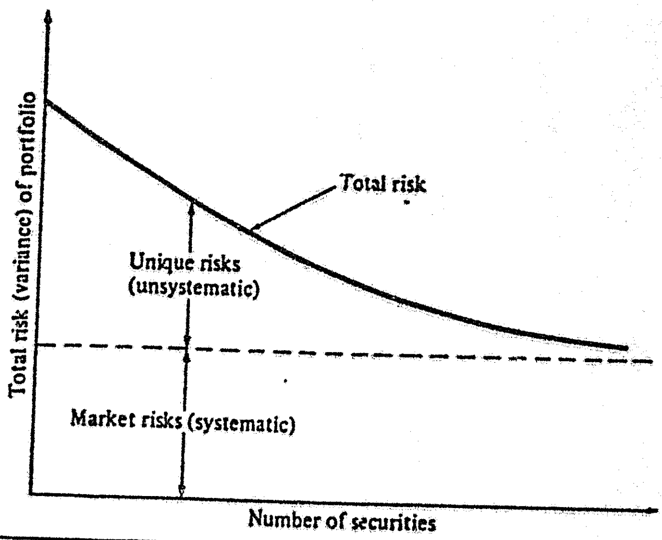
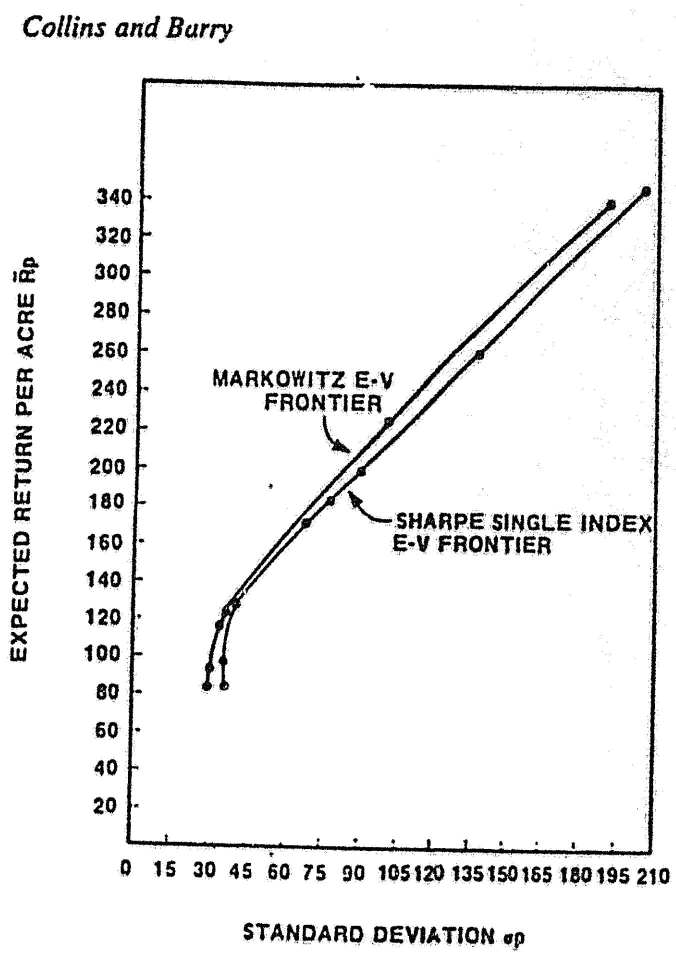


DIAGRAM 8

MARKOVITZ E-V FRONTIER AND SHARPE E-V FRONTIER
(after Collins and Barry, 1986).



conclude that the differences in enterprise risks are adequately captured by enterprise B's and an LP risk model is an accurate approximation to the full QP. They also note that the full QP includes non-systematic risk but the single index model excludes it but similiar results are achieved.

These overseas results suggest that exploration of these concepts would be worthwhile in New Zealand. Simplified programming requirements could make the method available to extension experts. The partition of total risk into systematic and non-systematic components should be explored. Since total risk is likely to rank in the same order as diversifiable risk (see Diagram 7) emphasis should lie on the relation of estimated B's to total risk as in the above analyses. Inflation presents a problem in estimating B's as a lot of the common trend is explained by this factor alone. Furthermore current extension advice should be couched in terms of present or expected prices and not in terms of historic prices. Some procedure is also required for negative B's especially where significantly different from zero.

An Example

Narayan(1990) reports an investigation of arable farm enterprises in the Canterbury region of New Zealand. This work explored the CAPM component of the problem and not the programming component. The intention here is to develop a user friendly programming approach. Briefly the Narayan results were as follows:

Activity returns were calculated for 11 crop and livestock activities on the Lincoln University mixed cropping farm for the period 1970-71 to 1986-87. Gross revenue per activity and gross margin per activity were derived and deflated values for both were derived using separate input and output price indices.

Four market portfolios were investigated comprising:

(i) an unweighted index of the component activities,
(ii) average survey returns for the region,
(iii) a weighted average of all enterprise groups in the country as a whole,
(iv) average production from the national income accounts
all expressed in per hectare terms.

Table 2 summarises the regression calculations for the 11 activities for the B coefficient. The table shows the descending order of riskiness for the activities using the unweighted market index and non-deflated gross margin as the norm. An asterisk signifies the estimated coefficient is significant at the 5 per cent level.

In nominal prices, gross revenue gives a similiar ranking except for one crop, process potatoes. Nine gross margin activities are statistically significant and 11 gross revenue

TABLE II

RANKING OF FARM ENTERPRISES BY THE CAPM

Crop	A: Unweighted Market Index			
	Nominal Prices		Real Prices	
	Gross Marg.	Gross Rev.	Gross Marg.	Gross Rev.
Fr Beans	1*	1*	2	2*
Fr Peas	2*	4*	11	11
Grass crop	3*	3*	3*	3*
Wheat	4*	5*	10	9
Grass catchcrop	5*	6*	5	5*
Sheep buy in	6*	8*	8*	10
Field Peas	7*	7*	6	6*
Sheep breeding	8*	11*	9	8
Barley	9*	9*	7	7
Clover catchcrop	10	10*	4*	4*
Process potatoes	11	2*	1*	1*

	B: Gross Margins: Nominal Prices			
	Unweighted	Survey	Production	GDP
Fr Beans	1*	1*	1*	1*
Fr Peas	2*	2*	2*	2*
Grass crop	3*	4*	4*	3*
Wheat	4*	3*	3*	4*
Grass catchcrop	5*	8*	7*	7*
Sheep buy in	6*	5*	5*	5*
Field Peas	7*	6*	6*	6*
Sheep breeding	8*	7*	8*	8*
Barley	9*	9*	9*	9*
Clover catchcrop	10	10	10	10
Process potatoes	11	11	11	11

* significant at the 5 % level

Source: Narayan (1990).

activities are statistically significant.

In real prices the ranking is much more broken up and the level of statistical significance is less. Process potatoes is again a marked exception. Only 4 activities are statistically significant with gross margin. This parallels the Collins and Barry results.

The four definitions of the market portfolio give very uniform results. These are constrained of course by the common assumption of non-deflated gross margins.

These results indicate very uniform risk ranking of the available farm enterprise in nominal prices but a very different picture for real returns. Turvey and Driver argue that inflation is part of the risk environment and that B should be estimated to include this factor. Collins and Barry could be concerned about the serial correlation effect in the regressions with the inflation factor exagerating the common fluctuations in each enterprise. Turvey and Driver (p 393) say that their measure of systematic risk captures inflationary effects common to all farm activities. On the other hand, the lack of significant results in the case of the deflated data suggests that there is limited common variation in the enterprises with the base set and this in turn reduces the scope for reduction of risk through diversification. In the jargon there is a low level of systematic risk in these activities.

As discussed further below, some farm management logic needs to be applied to these analyses to derive what is actually useful as compared with results which are more sound in theory. Portfolio analyses have shown that B is quite a stable statistic in many comparisions but individual details are often difficult to interpret (MacQueen,1986,p 52).

The Extension Implications

How should this material be presented in an extension programme? The measures of gross revenue and gross margin present no problems. However historic prices may provide no information as to the future nor may past variability relate closely to the future. It seems inescapable that the advisor will remain locked into whatever measure he has of the risk variability while current information on prices will be readily available. Clearly the ranking of enterprises from the profit point of view is not fixed in time and space. For presentation purposes the average of the last two years of the Narayan data is used here.

Table 3 shows the ranking of the 11 Narayan enterprises using the historic non-deflated means and the means of the last two years of the available series and the ranking in rising order of the diversifiable risk component. As Diagram 9 shows the low risk opportunities are grouped to the left and involve quite a range of mean historic returns.

The mean return-mean variance trade-off is more difficult to present. Does one explain B?! Diagram 9 shows a suggested graphical presentation of the mean returns and their respective coefficients of variation(CV). Here total risk and diversifiable risk are identified with the aim of explaining that by selecting crops of low diversifiable risk the farmer can reduce the total variance of his portfolio of enterprises. This assumes that systematic risk is out of his direct control.

Furthermore a simple linear programming (LP) framework could be utilised to set appropriate constraints on crop contracts, arable/pasture ratios and equipment restrictions, and sets of maximum net income enterprise mixes derived. In the absence of a full QP model, these enterprise combinations could be analysed in a software programme like the Minnesota "ARMS" package and mean income and variance estimates derived. These results would give a fairly close approximation to the risk efficient boundary for these enterprises and could be explained in terms of the greater risk attached to producing high-value high-risk crops.

Alternatively the traditional approach could be used and the LP exercise based on the measure of total risk. This would allow for the mean variance estimate to include all the expected variation in each crop and hence minimise total portfolio risk. The ranking of the enterprises from the risk point of view would be different in this case but not greatly different. Table 4 shows a comparision of the enterprise rankings using diversifiable risk, total risk and systematic risk as the sorting criteria.

Remember that the Collins and Barry and Turvey and Driver approach was to substitute B (or systematic risk) in the QP solution as the measure of inherent enterprise variability. Table 4 shows that quite a significant re-ordering of the enterprises takes place. The two enterprises with non-significant B's appear as the least risky! The high

TABLE 3

RANKING OF GROSS MARGINS AND DIVERSIFIABLE RISK

	Highest Historic Mean Margin	Highest Margins Last Two Years	Lowest Diversifiable Risk
1	Fr Beans	Fr Beans	Sheep breeding
2	Grass crop	Grass crop	Wheat
3	Fr Peas	Fr Peas	Fr Beans
4	Pr Potato	Wheat	Sheep buy
5	Wheat	Grass catchcrop	Grass crop
6	Field Peas	Field Peas	Fr Peas
7	Clover catchcrop	Sheep buy	Barley
8	Grass catchcrop	Pr Potato	Field Peas
9	Sheep buy	Sheep breed	Grass catchcrop
10	Sheep breed	Clover catchcrop	Clover catchcrop
11	Barley	Barley	Pr Potato

Source: Narayan, 1990.

TABLE 4

RANKING OF ENTERPRISES BY DIFFERENT MEASURES OF RISK

	Least Diversifiable Risk a	Least Total Risk b	Least Systematic Risk c
1	Sheep breed	Barley	Pr Potato
2	Wheat	Sheep breed	Clover catchcrop
3	Fr Beans	Grass crop	Barley
4	Sheep buy	Clover catchcrop	Sheep buy
5	Grass crop	Wheat	Field Peas
6	Fr Peas	Field Peas	Sheep breed
7	Field Barley	Fr Peas	Grass catchcrop
8	Field Peas	Sheep buy	Wheat
9	Grass catchcrop	Fr Beans	Grass crop
10	Clover catchcrop	Grass catchcrop	Fr Peas
11	Pr Potato	Pr Potato	Fr Beans

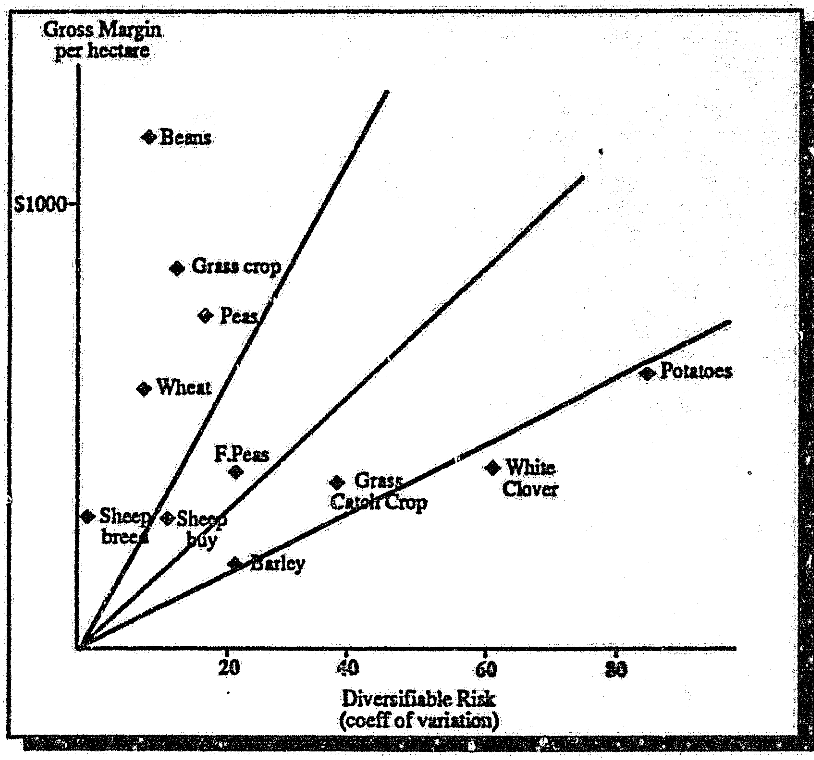
a based on CV of root of unexplained variance,unweighted portfolio and non-deflated gross margin

b based on CV of root of enterprise variance

c based on estimated B coefficient for each enterprise using unweighted portfolio and non-deflated gross margin.

Source: Derived from Narayan, 1990.

DIAGRAM 9:
MEAN RETURNS AND DIVERSIFIABLE RISK
(after Narayan 1990)



value crops have the highest B's. In technical terms it is perhaps not surprising that there is not a high degree of correlation between the historic variance of each enterprise and its B coefficient. This kind of evidence suggests that the claims of the above authors need to be further evaluated in more diverse production conditions.

As far as the extension problem is concerned, visual displays of enterprise ranking by risk and by mean expected returns could be explored. The relevancy of one lot of data to other districts would have to determined. Further work should indicate which measure of risk is most appropriate. Lap-top computors could be programmed to analyse simple LP propositions and risk packages utilised to derive mean-income mean-variance portfolios of available enterprise choices. (Could such information have prevented the wholesale and largely unprofitable entry into deer and goat farming in New Zealand in recent years? Have Applefields made the right decision to diversify into dairy production?).

Narayan (1990) concludes his analysis by observing that the high degree of systematic risk in his undeflated models implies that off-farm diversification may be a more appropriate strategy than on-farm diversification. Also that deflated models showed that both systematic and non-systematic risk were present which imply that both on-farm and off-farm diversification may be appropriate.

Kaplan (1985) reports a study of mixed portfolio investment which included farm real estate. He assumes that portfolio holder is an investor and not a farmer. In one comparision he compares farm real estate values in the US with large capitalisation stocks, small capitalisation stocks, long-term corporate bonds, long-term government bonds and US Treasury Bills. He observes that farm real estate gave three times the return on Treasury Bills but was considerably more volatile! Using a measure of risk-efficiency of additional nominal returns per unit of standard deviation (SD) he rates farm real estate as having the highest risk efficiency of the stocks examined. Kaplan also constructs a model of net returns from 81 crop regions in the US, including capital gains, using 25 years of data. Groups of regions are assessed from a returns-variance point of view and the author finds that whereas the mean return on the set was 13.5% the optimum return was 17.1% for the same SD. He concludes that 5 regional farm units, suitably chosen, would make a satisfactorily diversified portfolio of land investment. This taken with his earlier conclusion that farm real estate was an efficient risk investment compared with stocks suggested to him that institutional investors should be interested in farm real estate.

In a survey of New Zealand farmers Newman et al (1990) found that they were not entirely rational in their choice of alternative investments. "If surplus money arises from a good farming year most would be used for re-investment in the business, either through debt reduction or asset replacement.

The proportion used for such re-investment would however be significantly decreased if the same sum were to be won in a lottery or inherited. In these instances, a higher percentage of the surplus funds would be applied to personal expenditure and off-farm investment" (Newman et al, p 84). The above results suggest that further investigation is required into off-farm diversification issues as well as the merits of portfolio investment in rural land.

ARBITRAGE PRICING THEORY

Arbitrage Pricing Theory (APT) provides an alternative approach to the definition of a risk-free portfolio compared with the Capital Asset Pricing Model (CAPM). APT assumes that a small number of common factors cause co-movements among asset returns. These factors are the sources of systematic risk. In competitive financial markets arbitrage ensures that riskless assets provide the same expected return; security prices adjust as investors form portfolios in search of arbitrage profits (Van Horne 1989). Factor analysis is therefore used to isolate common movements in security prices and to estimate an individual security's systematic return. The residual return from actual is regarded as a chance element as in the CAPM.

Roll and Ross (1980) proposed that four different factors can be considered systematic (as reviewed by Newman et al 1990). The set includes unanticipated changes in inflation, unanticipated changes in industrial production, unanticipated changes in the bond default premium, and unanticipated changes in the yield structure of interest rates.

Arthur, Carter and Abizadeh (1988) report a US study comparing the APT and the CAPM. They observe that agricultural assets are not very risky when included in a well-diversified portfolio. Insignificant systematic risk associated with agricultural assets implies that their expected return should be relatively low. The authors set out to test this hypothesis through the two models using data for fourteen US farm assets and five non-farm assets. The point of view is that of the investor and not of the farmer. Both models confirm low systematic risk in farmland and spot commodities with the exception of gold, cotton, fruit, tobacco, dairy/eggs, hay and corn. The authors say however that their conclusions are stronger for APT because the model explains the relatioship between risk and returns better than the CAPM. It is noted that the factor analysis involved in APT is much more complex and requires several stages of analysis compared with the apparent simplicity of the CAPM estimation procedure.

It should also be noted that Arthur et al are comparing prices of commodities and land where land return is defined as the dividend from farm real estate. This probably explains the different conclusion of the Kaplan study where farm land was compared with stocks and bonds. Arthur et al are also looking for systematic risk while Kaplan is looking at total risk as expressed as the SD of each stock and land. Further research is needed to clarify the respective merits of the two approaches taking into account the added complexity of the APT methodology.

OPTION PRICING THEORY

At first sight option pricing theory (OPT) appears to have very little to do with investment criteria. However an option on buying a share that has some uncertain future value must take account of expected variability or volatility of the share. In option pricing the volatility of the underlying asset is measured by past performance. The greater the volatility the greater the "upside potential" (Brearly and Myers, 1984, p 443). This is because there is a greater chance of a bigger pay-off on a more volatile stock. Furthermore the value of an option depends on the time to maturity, the interest rate, the exercise price, the market price as well as its volatility. These factors are all summed up in the Black-Scholes formula which is based on the value of an option equivalent (Brearly and Myers, p 447).

Option pricing is an appropriate approach to investment situations where risk changes when other factors change and the opportunity cost of capital cannot be derived. An example may be an irrigation investment which raises net returns but also changes the variability of the resulting cash flow. Or as discussed below in the case of a major policy change which confers a set of rights on the policy beneficiaries which have a range of possible future values. These changes in risk are not picked up by conventional cost-benefit analysis hence the value of an alternative approach.

An option is not exercised if the transaction makes the holder worse off. This introduces an element of management to the investment decision. The holder wants to take account of future variability of returns and asset values. In financial markets when the values of underlying assets have higher variability the options have higher value because there is more chance of the option being worth something. OPT provides the methodology to value this variability in asset prices from the point of view of the beneficiary. Therefore the fiscal cost of the risk reduction policy is likely to differ from and probably understate the value of the policy to the beneficiary.

Seed (Pers.comm.) reports that a debt discounting policy such as that introduced in New Zealand in 1986 could be evaluated from this point of view. "The Rural Bank debt discounting policy ...reduced the financial risk (defined as the degree of financial leverage) of the policy beneficiaries. The programme was intended to compensate agricultural producers for adverse events that had detrimental impacts on income, asset values, equity positions and solvency. At the same time the policy also gave financiers the chance to improve the security margins on loans to farmers who were technically insolvent....From the point of view of the donor,ie the government, the "cost" of the policy was the fiscal cost voted through the annual budget allocation of the agency administering the programme. However as asset values are dynamic it is quite likely that the value of the programme to both beneficiaries could be significantly different from the cost to the donor over time".

By reducing debt, the programme improved the equity positions of farmers and reduced the portfolio risk of the lenders. However, the farmers will also benefit from the policy if land prices rise in the future. OPT takes account of the potential for asset values to rise and will therefore put a value on the potential for a future improvement in equity positions. Seed is currently developing a methodology to use OPT to value the debt discounting policy from the point of view of the beneficiaries on an ex post basis.

Another application would be to substitute OPT in a discounted cash flow (DCF) model. Such an analysis would then clarify whether risk should be incorporated in the discount rate - as CAPM suggests, or whether risk-free interest rates should continue to be used. OPT would obviate the need to generate future streams of cash flows and sensitivity analysis based on some form of "monte carlo" modelling. OPT would approach this problem from some record of previous variability or volatility. Finally, OPT would obviate the need to estimate an appropriate discount rate as it explicitly accounts for the risk or variability of the cash flows associated with a development. Some experiments would obviously be useful in this area and would clarify for example the "value" derived from reduced risk in the irrigation development case.

CONCLUSIONS

This review confirms that there are considerable insights from corporate finance literature that illuminate our understanding of risk and decision making in the farm firm. Further research is needed to clarify a number of topics including the limitations on excessive use of tax shelters, optimum enterprise choices under uncertainty, the arbitrage alternative to the CAPM, and the use of option pricing models instead of, or to supplement, standard discounted cash flow analyses. It remains unclear without further work whether risk-free interest rates should be used for discounting or the CAPM variant adopted. It is also unclear whether discount rates used as capitalisation rates should be on a pre or a post-tax basis in the WACC calculation. Further work is needed to exactly understand how these conceptual constructs operate in the agricultural sector and how much our tried and true models of the past can continue to be useful in the future.

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