Review
Risk and the Farm Firm: A Corporate Finance View

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Recent applications of risk analysis in corporate finance to farm firm decision making are reviewed in this paper. The inclusion of risk parameters modifies some of the traditional agricultural economics views on investment, financing and the portfolio choice problem. A clearer view emerges of farm investment behaviour. Further topics for research are identified. In the author's view, the corporate finance analysis provides a more coherent set of paradigms that explain actual farm investment and financing decision making in a more satisfactory way than previously available.

1. Introduction

Over the last 40 years a considerable literature has developed on the application of risk concepts to corporate finance decision making. A recent review is provided by Stern and Chew (1986). There are two main strands of development. The trade off between risk and mean returns is exemplified in the work of Markowitz (1952) and his many successors. This has led to many farm programming model applications and also to the derivation of individual components of risk as exemplified in the capital asset pricing model (CAPM). The second strand concerns capital structure decisions. Here the work of Modigliani and Miller (1958) is the starting point for detailed analysis of optimum capital structure in the firm, the role of tax shields, and the risk weighted return on equity. There is a common link between the two strands through the capital asset pricing model; the model identifies common or systematic risk in past performance criteria and uses the information to aid both the portfolio selection problem and the estimation of the risk-adjusted cost of equity.

In this review, the definitions of risk are first described, followed by a brief introduction to the corporate finance view of capital structure, portfolio theory and risk, and asset pricing models. Each of these topics is then examined from the viewpoint of the farm firm to draw comparisons with the agricultural economics literature, to derive an ongoing research agenda, and to suggest what insights can be obtained for the agricultural economics profession.

2. Basic Concepts

2.1 Systematic risk

In the economic model of the firm, risk is taken to mean any threat to the outcome or results that are planned. Any chance of not achieving or over-achieving an outcome constitutes risk. Normally under-achievement is focussed on as "down-side" risk. The causes of these fluctuations in outcomes are many and various - be they classed as business risks (caused by operating procedures), financial risks (caused by leverage), or market risks (uncertainty about sales outcomes)(Pringle and Harris 1987, p.480). From the point of view of this analysis the most important category is risk arising out of 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). This category of risk is called systematic risk because it is common to all firms. The CAPM addresses this type of risk as does the arbitrage pricing model (APT).

Residual risk or variation (non-systematic risk) is not accounted for in the CAPM. It is inherent in the individual activities of the firm. The theory views this as a problem for management to reduce or eliminate such risk by appropriate diversification strategies (Rosenberg and Rudd 1986, p.60).

Models of firm capital structure define the risk concept as a safety margin over a risk-free or base

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return on equity set at a level to provide for most contingencies (Pringle and Harris 1987). Without leverage, the margin includes all business risk and excludes financial risk. Borrowing increases risk of failure, hence total risk is the sum of business and financial risk. Conceptually, these margins do not distinguish between systematic and non-systematic risk.

In portfolio selection, total risk is minimised by appropriate selection strategies. Portfolio models use measures of variability based on past records as indicators of future variability. Single index models (based on CAPM) identify the systematic component of risk as expressed by the so-called β coefficient. Future trends in β's are forecast from past performance.

There are thus important distinctions between risk as a desired rate of return, risk as possible fluctuations on the return to a share, and the CAPM measure of risk. The first is a firm-oriented margin in expected investment returns to equity to cover both business and financial risk. The second is about a strategy to reduce an investor's total risk by spreading investments, and the third is a strategy to reduce systematic risk. In farm enterprise applications using CAPM the latter is expressed as a margin in a group of firms to cover economy-wide uncertainty about outcomes but excluding management efficiency. In the literature, CAPM is sometimes applied to the capital structure rate of return and hence changes the notion of risk which is being measured.

2.2 Capital structure

The optimum capital structure model uses the distinction between business risk and financial risk. Increased leverage adds to the margin on equity returns that is prudent for the average operator. Since the average cost of capital is the weighted average of risk-adjusted equity return and cost of debt, increased leverage means there are forces at work which reduce the average cost of capital (Van Horne 1983, p.249; Hawkins and Pearce 1971, p.58). The corporate finance literature is concerned to analyse the limits of leverage effects on the cost of capital and the reasons for finding an optimum level of financing. Furthermore the results of the analysis are modified considerably when fiscal considerations are taken into account (Stern and Chew 1986, p.95). Analysis of the farm firm reveals that the lack of a corporate structure modifies the theory still further (Collins 1985, p.627).

2.3 Portfolio selection

Portfolio theory posits a relationship between expected return and variability. "The investor must contemplate the various efficient combinations of average returns and standard deviations. He must choose one combination of average and standard deviation which, more than any other, satisfies his needs and preferences with respect to risk and return" (Markowitz 1952, p.79). The theory states that the combination of two shares, the returns of which are not fully correlated, will provide a combined volatility that is less than that of either share. The investor can reduce volatility by seeking a portfolio of shares of small or negative correlation while maintaining average return. The framework uses three pieces of information; the expected return on a share, the standard deviation of the return, and the covariance between returns. The standard deviation is a proxy for future risk and the covariance measures the degree of association between each series.

Individual investors will have different attitudes to risk and hence will prefer different combinations of average return and risk. The risk efficient frontier is defined by the opportunities available and the probability of success. It defines the best return for a given risk or the lowest risk for a given return. On the other hand, the individual's position on the frontier curve will be determined by his/her relative utility between risk and return. At the point of tangency of the risk frontier and the individual indifference curve, utility is maximised.

Portfolio theory has been applied to the farm enterprise selection problem with good results (see for example Lin, Dean and Moore 1974; King and Robison 1984). The selection of an optimal farm plan, through the process of evaluating and measuring enterprise returns and variability, and consideration of farmer preferences for risk and profit, uses the risk frontier concept. The programming load is high in these studies and a number of simpler models have been tried (these are discussed below).

2.4 Capital asset pricing model

The CAPM was put forward in the 1960s as one answer to the huge data handling problems of full Markowitz risk-return analysis (Sharpe 1964; Lintner 1965). Individual share prices are related to a general portfolio of shares based on some weighted average of all shares traded, the market index. The returns on the individual shares are assumed to be related to each other through common dependence on the market index and hence the necessity to specify the covariance of returns between every pair of shares is avoided.

The relationship can be expressed in the following way:

(1) $R_i = a_i + \beta (R_m) + E_i$

where R_i = rate of return on a single share

a_i = average value of non-systematic returns over time

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

β = beta or relative risk of share in question

E_i = an error term.

Thus the estimated value of β (commonly from time series data) indicates whether a share is more or less volatile than the average. The estimates are sensitive to the selection of the data in the market index. In the programming solution there is now no requirement for direct estimates of the joint movements of the return on shares, only an estimate of the manner in which each share moves with the market index i.e. its β. From this base other applications of CAPM have been developed which are referred to later.

More recently, the same reasoning has been applied to the farm enterprise selection 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 1986, p.152).

In this case R_i becomes the net revenue on enterprise i; R_m is the average net revenue from a "portfolio" of enterprises and β measures the amplitude of common fluctuations in the returns to the single enterprise in relation to the average. The coefficient a_i can be interpreted as the difference between the expected return from the asset and the total portfolio. The proportion of the fluctuations in a single enterprise or activity that is common to market risk is called systematic risk and the residual variation is called non-systematic. The authors quoted have demonstrated that modified quadratic programming solutions to the farm enterprise selection problem can be obtained that are closely compatible with full Markowitz programming.

2.5 Arbitrage pricing theory

APT provides an alternative approach to the definitions of a fully diversified portfolio or market index. APT assumes that a small number of common factors cause co-movements among share or asset returns. These factors are the source 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. Factor analysis is used to isolate such common movements in security prices and to estimate an individual security's systematic return (Van Horne 1989; Roll and Ross 1980; Bower, Bower and Logue 1986).

Roll and Ross (1980) propose that four different factors can be considered systematic; unanticipated changes in inflation, unanticipated changes in industrial production, unanticipated changes in the bond default system, and unanticipated changes in the yield structure of interest rates. Arthur, Carter and Abizadeh (1988) report a United States study comparing the APT and the CAPM. For the CAPM the market index used is the Standard and Poors 500 series and for the APT the portfolio includes municipal bonds, agricultural commodities, farm real estate, gold, three foreign currencies and stock market indices. They observe that agricultural assets are not very risky when included in a well-diversified portfolio. Systematic risk levels were low. APT analysis reflected this property more accurately than CAPM.

3. Optimal Capital Structure

3.1 The corporate view

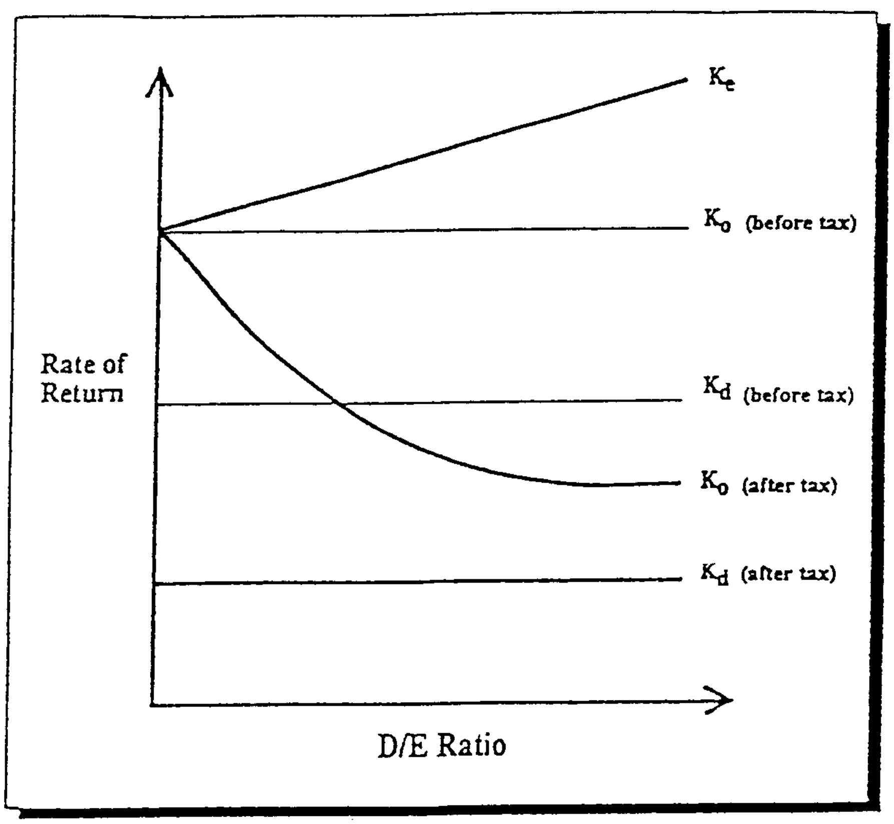
By capital structure, corporate financial analysts mean managing debt and equity to reach the corporate firm's objectives (Myers 1986, p.91). They ask whether there is such a thing as an optimal capital structure, and whether borrowing (leverage) has any real benefits? They ask whether debt financing can get out of control? (Stern and Chew 1986, p.89). The corporate finance view of optimal capital structures has been highly influenced by the work of Modigliani and Miller (1958) (MM henceforth). The cost of capital is taken as the weighted average of debt cost and required equity return (WACC). Required equity return incorporates business and financial risk premiums (Figure 1). As before, 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. K_d is the cost of borrowing, K_e is the required rate of return on equity, and K_o is the weighted average of the two. 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.

MM 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. The price of stock rises or falls as the debt level changes. The lowering of the price/earnings ratio is proportional to the rise in the debt-equity ratio through arbitrage.

3.2 Farm firms

In considering farm firms, the conditions assumed

Figure 1: Tax Effect on Weighted Cost of Capital



by MM no longer apply. The structure of equity held by proprietors means that there is not an efficient market for equity where the equity capitalisation rate can freely compensate for increased debt (Collins 1985). In this case it is hypothesised that the proprietor's views on financial risk will determine the shape of the K_e 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.

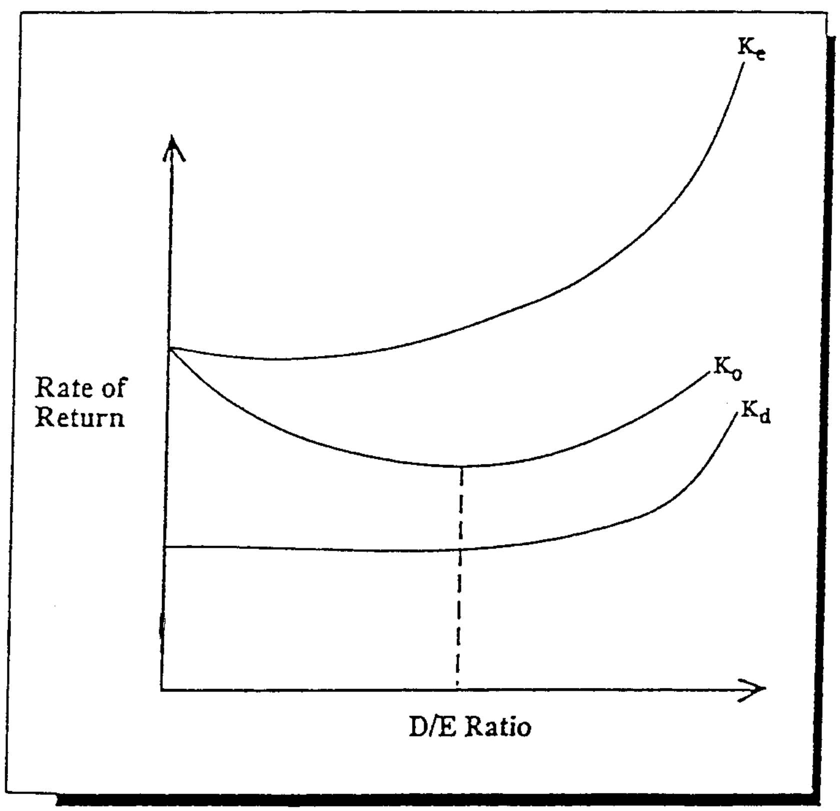
This situation - called the traditional approach in the literature - suggests that the average cost of capital will at first fall with increased leverage and later rise again as the financial risk dominates the situation (Figure 2). Financial risk is seen as an increasing function of leverage. In this case, therefore, there is a gain to the proprietor in moving towards some middle position of debt and equity mix. The minimum point on the K_0 curve represents the least cost combination of the sources of capital. This is common to many agricultural finance texts (see, for example, Penson and Lins 1980, p.188).

3.3 The limits of borrowing

The increasing function of required equity return with leverage is associated with an increasing probability of bankruptcy and with distress costs. Distress costs occur when a firm's cash flow falls below expectations (Van Horne 1983, p.262; Bishop, Crapp and Twite 1988, p.138). Costs are incurred in modifying investment and finance strategies. Investment given up will have 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 leverage at the limit is increased agency or monitoring costs (Van Horne 1983, p.272).

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 risky environment, prudent limits need to be determined, dependent upon the threat or probability that changes in both business risk and financial risk could affect

Figure 2: The Traditional Approach to Weighted Cost of Capital



the continuation of the business. Such arguments apply equally to corporations as to single proprietors.

3.4 Tax shields

MM subsequently modified their position on invariate average cost of capital (Miller 1977; Myers 1986, p.94). Corporate tax legislation allows firms to deduct interest on debt. This represents a gain to the firm or a loss to Government revenue. Higher leverage decreases the share of pre-tax operating profit going to the Government and increases the share going to equity (Pringle and Harris 1987, p.494). The firm's cash flow to owners increases with leverage because of the tax exemption provided by interest on debt.

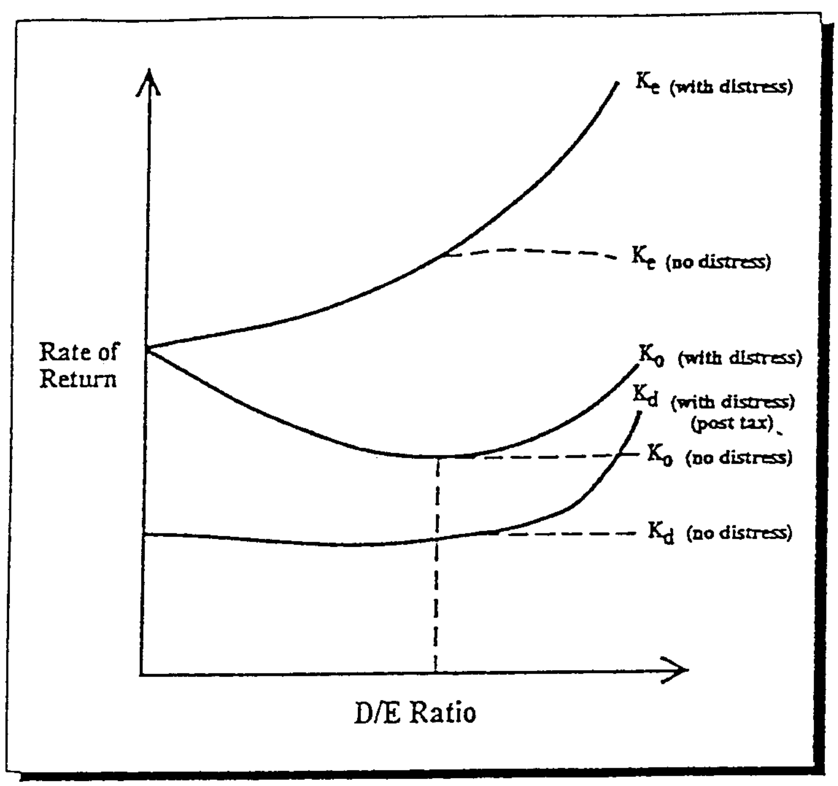
Another way of stating the same proposition is that the present value of a firm's future cash flow is enhanced by the present value of future tax shields. This enhancement is often captured in takeovers.

Introducing tax to the WACC formula changes the compensatory relationship postulated by MM. Lower effective cost of borrowing disturbs the price/earnings relation and the weighted average cost of capital falls as debt increases (as in Figure 1). This conclusion only holds, of course, if the firm is making taxable profits.

The question then arises as to what constraints there are on unlimited exploitation of tax shields? Van Horne (1983, p.272) suggests a modified 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 (Figure 3). The firm can be portrayed as balancing the value of interest tax shields against various possible costs of bankruptcy or other financial embarrassment. The effect is to reduce the optimum debt equity ratio for the firm as financial stress affects the K_e parameter (Myers 1986, p.95; Pringle and Harris 1987, p.499). Indeed, lenders are also affected by the distress signals and K_d may also rise with consequent effects on K_o.

Such changes shift the burden of distress costs to

Figure 3: Tax Effect with Distress Costs



the equity holders and the valuation of equity falls (Bishop, Crapp and Twite 1988, p.313). The required return of equity holders also increases. These conditions thus determine that the firm's K_o curve will be u-shaped and not continuously sloping downward. At the optimum the tax advantage from leverage is equal to the expected loss from distress costs. Bishop *et al* maintain that the compensatory mechanism between debt return and equity return operates in the corporate world, even though average cost is no longer invariant with rising debt as in the original MM proposition.

3.5 Tax and the farm firm

For farm proprietors the effects of the tax shield are similar. The K_d curve is pushed downwards with more lift in its tail. The K_e curve tends to be more steeply curving away from the axis as debt rises (Figure 2). As a class farmers do not like a lot of debt. Proprietors benefit from lower post-tax interest costs as long as they make profits. After a point debt-holders only lend to them at greatly increased premiums, hence the average cost of capital at first falls moderately but then rises again as their required return on equity increases rapidly. The net result is a general drop in the level of the K_o curve and a movement to the left of the optimum debt-equity ratio.

McCrea, Grundy and Hay (1990) report an evaluation of tax shields in the farm firm in representative farm development situations. The highest present value of tax savings occurred when fast development took place, when market interest rates were used instead of subsidised rates, and when higher pre-1985 tax allowances were used. The present value estimated was 1.5 per cent of total capital value. Larger investments in relation to the base would generate higher tax savings.

A broader programming approach would have to be adopted to evaluate uncertainty at the margin and thus test Myer's proposition (1986, p.101) of a static trade-off between tax shields and costs of bankruptcy or financial embarrassment. Further work and evidence in this area would certainly be useful.

4. Investment Criteria and Risk

4.1 Basic concepts

The use of risk adjusted rates of return opens up a different approach to discounted cash flow analysis (DCF). Further the impact of tax shields is also relevant to the valuation decision in corporate or single proprietor enterprises. The WACC definition includes the risk component in its parameters. If V is total value, E is equity and D is debt, then:

$$(2) \qquad \text{WACC}\ (K_o) = \frac{D\,K_d}{V} + \frac{E\,K_e}{V}$$

and if post tax (1-T) borrowing costs are appropriate as discussed below, then:

$$(3) \qquad \text{WACC}\ (K_o)^* = \frac{D(1-T)K_d}{V} + \frac{E\,K_e}{V}$$

This concept of a risk weighted rate of return is quite different from deriving social cost-benefit discount rates from risk free rates of interest. In the latter risk factors are usually incorporated in the cash flows and discounted at the risk free rate. A higher risk-adjusted discount rate would put more emphasis on short and medium term projects and preclude longer-term projects. Also rates of return at risk free rates would appear to decision makers as favourable if the risk range was expressed as a present value above and below the mean. Success in public projects is no more assured than in private projects hence there appears to be little justification for bumping up public projects with deceptive estimates of rates of return.

Private decision makers could also more carefully scrutinise their discount rate assumptions. A new project should be evaluated on the basis of the borrowing rate likely to prevail at the time and on a return to equity which is appropriate to the firm's activities. Some analysts say that the return on equity should incorporate the risk on the project and not that of the firm as a whole. In all cases the decision to go ahead should be based on cash flows and risk levels that make the firm better off and not worse off, i.e. earning a rate or using an opportunity cost equivalent to the best alternative of equivalent risk (Bishop, Crapp and Twite 1988, p.320).

Should farm firms use a pre- or post-tax rate of return for discounting? Corporate practice is to use post-tax rates of return on a dividend basis as a guide to investment. It appears that farm proprietors would be fooling themselves if they did not do the same thing. The analyst should perhaps carry out both analyses as there could be circumstances where the tax break gives a perverse result. In general one would expect the present values to rank projects in the same order in most cases.

Social cost-benefit analysis should continue to use pre-tax rates as the result will be interpreted from the national viewpoint. In this case tax is a transfer payment among beneficiaries and does not influence the overall result.

In the private viewpoint the balance of opinion favours the post-tax rate. Comparisons with pre-tax rates could give false answers as in the case, say, of a present value of a future income stream like land productive value (or stumpage value in forestry) and conclusions could be misleading without checking basic assumptions (Anderson 1990). This also applies to analysts who use use simple capitalisation rates as proxies for discount rates.

Experience suggests that the tax shield can influence the purchasing decision and hence the market value of land. The market for land is not independent of tax structures. Thus land purchase is part of the private sector market process and evaluation of returns should explicitly consider the tax factor.

4.2 Measuring the required rate of return on equity

If proprietors are going to use a risk weighted rate of return for discounting how are they going to measure it? By definition the rate will vary according to the debt-equity ratio and the individual's preferences between mean return and risk. Intuitively the chosen rate should be a considerable margin over the borrowing rate to cover normal business risk and financial exposure (see Figure 1).

The CAPM offers a formula for calculating the systematic risk component in each case (Shim and Siegel 1986, p.249). The risk adjusted cost of equity is defined as:

$$K_e = R_f + \beta\,(R_m - R_f) \qquad (4)$$

where $R_m - R_f$ = the average equity risk premium of some portfolio over a risk free rate such as a five year government bond,

and β = beta or relative risk of the investment in question.

CAPM thus estimates one risk margin for all relevant investments. This formulation substitutes systematic risk for total risk, and thus assumes that diversifiable risk is not present or can be managed internally.

Further case studies are required to explore the potential of this approach. It is clear that the higher the risk premium, the lower will be the present value of the income stream and hence the less that should be paid for the asset involved.

Given these uncertainties about the valuation of the land asset, it is not surprising that access to land ownership is a political issue in Australia and New Zealand. In New Zealand starting farmers have been heavily assisted by the State. Lending has been subsidised, loans have been guaranteed, price stabilisation schemes put in place, and tax concessions provided. Some or all of the business risk was transferred to the State and other institutions (marketing boards) and the starting farmer was able to take on a high level of financial risk. With the removal of these supports in recent years, the purchaser is exposed to the full risk in the market place and much more conservative financing and pricing of the land asset has resulted.

4.3 Option pricing theory

There are cases where the DCF approach does not provide an accurate reflection of risk parameters. Such cases include circumstances where projects are modified or started up again and where the risk parameter itself is changed by the project (Brennan and Schwartz 1986, p.80). Examples of the former are mining projects which can be closed down and started up again. This fact reduces the downside risk to the investor. Examples of the latter would be an irrigation scheme where returns are raised and the risk of output fluctuations lessened. Option pricing enables a value to be placed on the change in risk status.

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 by the Black-Scholes formula which is based on the value of an option equivalent (Brearly and Myers 1984, p.447).

Seed (pers. comm.) suggests that debt write-offs by the State is a case where the risk parameter is changed by Government action. Farmers are beneficiaries since their assets are more secure than they would have been if Government had not stepped in. The Black-Scholes formula can be used to estimate the extra "value" to the farmer created by State action. Bardsley and Cashin (1990) examine the situation where guaranteed prices for a commodity are regarded as a put option. A guaranteed price creates a value through the level of assistance potentially available, hence the true value of the assistance is greater than actual payments made because of this upside potential. Such an underwriting arrangement can be assessed by estimating the cost that producers would otherwise have to have paid to obtain the same cover (through put options) equivalent to the guaranteed price.

These observations open up a new area of research for agricultural economists. There would be cases where DCF analysis could be supplanted by OPT. It would be particularly useful to have case studies where the risk parameter changed, analysed by both DCF and OPT. The precise role of the risk-adjusted discount rate would need to be analysed.

5. The Portfolio View of On-farm Investment

5.1 Emphasis on systematic risk

The introduction of the CAPM into the farm enterprise selection problem was aimed at simplifying the full-blown Markowitz approach (section 2.4 above). The emphasis lay on presentation of the material in extension frameworks. The use of CAPM thus focuses attention on the management of systematic and non-systematic risk in the farm firm situation.

Systematic risk is general or common risk faced by all proprietors. The CAPM measures the amplitude of the variability of an individual investment opportunity consistent with the definition of systematic risk. The theory states that this is a sufficient condition for risk minimisation because the remaining risk (non-systematic risk) is inherent to the individual activity. The function of management is to control and/or eliminate non-systematic risk through appropriate diversification strategies and capital markets will not reward investors for bearing such risks (Rosenberg and Rudd 1986, p.60).

In technical terms CAPM substitutes a measure of relative risk for the measure of total risk used in earlier Markowitz solutions. Collins and Barry (1986) show that any solution using the CAPM single index method will always lie inside but near the Markowitz frontier due to its lower level of accuracy. Because the estimation of risk variability changes it is also likely that the ranking of different investment opportunities could also change.

5.2 Case studies

Collins and Barry (1986) take a spread of Imperial Valley crops to compare a quadratic programming (QP) approach to the CAPM approach. They demonstrate that the contribution to the income variability of a well-diversified firm by a particular activity is proportional to the β coefficient. Turvey and Driver (1987) present empirical estimates of enterprise β coefficients for Ontario cropping and livestock farms at the gross revenue level. This work identifies the importance of nominal and real prices and of market index definition in the resulting estimates of β. Turvey, Driver and Baker (1988) examine a combined cash-crop, beef feed-lot operation in southern Ontario. Their CAPM results are stated to be fully consistent with full QP results and to fully capture total risk exposure.

Narayan (1990) reports an investigation of arable farm enterprises in the Canterbury region of New Zealand. Enterprise data for the Lincoln University farm were examined to identify nominal and real real price assumptions, four alternative definitions of the market index, and the measurement of enterprise returns at the gross revenue and the gross margin level. Different definitions of the market index gave similar rankings to each of the enterprises. Gross revenues give similar rankings to gross margins. Only real and nominal price comparisons tend to give different rankings though within each, revenue and margins remain consistent.

Turvey and Driver (1987) argue that inflation is part and parcel of the systematic risk environment and that β should be estimated to include this factor. Collins and Barry, on the other hand, are concerned about serial correlation in the enterprise data using nominal prices. Narayan's work shows that not only are the rankings different but that fewer enterprises provide statistically significant estimates in the deflated data. Thus the degree of systematic risk found is affected by the methodology used.

A test of the effect of the risk definition used and the consequent programming results to be expected can be devised by ranking enterprises according to the different definitions of risk (Table 1). The eleven Narayan enterprises are ranked according to total risk, systematic risk and non-systematic measures as defined in the table. Remember that Collins and Barry and Turvey and Driver wished to substi-

Table 1: Ranking of Enterprises by Different Measures of Risk

(least risky first)

	Least [a] Non-systematic Risk	Least [b] Total Risk	Least [c] Systematic Risk
1	Sheep breeding	Barley	Pr Potato
2	Wheat	Sheep breeding	Clover catchcrop
3	Fr Beans	Grass crop	Barley
4	Sheep buy in	Clover catchcrop	Sheep buy in
5	Grass crop	Wheat	Field Peas
6	Fr Peas	Field Peas	Sheep breeding
7	Barley	Fr Peas	Grass catchcrop
8	Field Peas	Sheep buy in	Wheat
9	Grass catchcrop	Fr Beans	Grass crop
10	Clover catchcrop	Grass catchcrop	Fr Peas
11	Pr Potato	Pr Potato	Fr Beans

Fr. = Frozen; Pr. = Process

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 β coefficient for each enterprise using unweighted portfolio and non-deflated gross margin.

Source: Derived from Narayan (1990).

tute systematic risk for total risk measures. This simple demonstration shows that a quite significant re-ordering of enterprises takes place as the definition of risk changes. In effect the common variation to all enterprises is different from total variation of each on its own. This has the implication that advice to farmers (as suggested by Collins and Barry 1986) could be confounded by methodological issues beyond their understanding.

5.3 Discussion

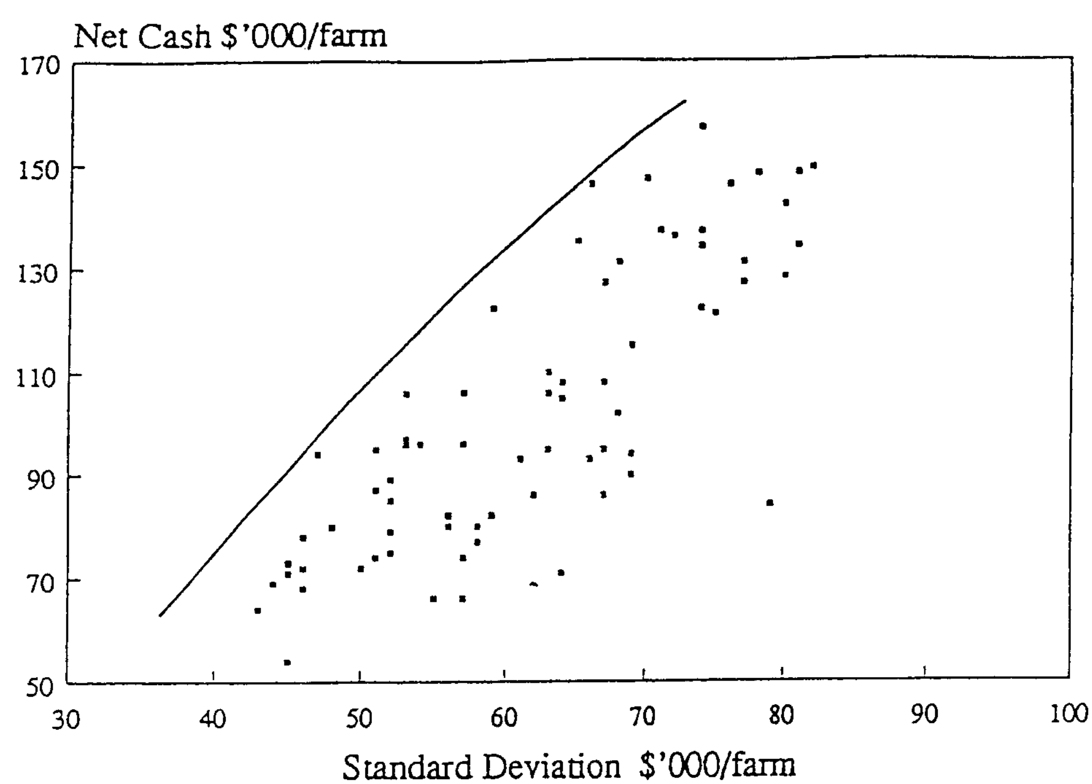
The Collins and Barry (1986) objective of more explicit extension advice would need to be developed from the data bases discussed above. There would be a need to use current or forecast product prices for crops and livestock and to derive risk coefficients from equivalent historic data for each enterprise. The use of the β coefficient could be tested in the field. Simple linear programming software could be adapted to field use and individual advice provided. Narayan and Johnson (1991) report further such analysis using the Narayan data (Figure 4). These results were derived using the Minnesota Agricultural Risk Management Simulator (ARMS) software package. Total risk is used in this example and different enterprise combinations in groups of four are evaluated. After sufficient replication and combinations, the risk efficiency frontier is effectively described for the farming system involved.

6. The Portfolio View of Off-farm Investment

6.1 Implications for farm proprietors

The discussion in this paper indicates that off-farm investment could be part of farmers' risk portfolios. A high degree of systematic risk in on-farm investments indicates that outside investment could lower overall risk (Narayan 1990). Such high systematic risk implies that most internal diversification strategies have been adopted. Such hypotheses clearly need testing by careful evaluation of farmer preferences and opportunities. There is some evidence that New Zealand farmers put a higher value on reinvestment in their farms than in off-farm protec-

Figure 4: Risk Efficiency Frontier for Lincoln University Farm



tion from the inherent risks of farming (Newman *et al* 1990, p.84). It is also plausible that recent changes in State assistance and marketing arrangements have increased the inherent risks of farming and hence increased the need for more balanced investment portfolios. This is an area for further research.

7. Conclusions

The main purpose of this review was to determine how the incorporation of risk in capital structure, investment and financing paradigms affected agricultural economics thinking.

Corporate analysis lays considerable stress on optimum capital structure and the limits to borrowing. Tax shelters are shown to be influential in defining the optimum. In non-corporate enterprises like farming, risk aversion to financial exposure appears to be the main influence on the position of the optimum. The value of typical agricultural tax shelters can be estimated by appropriate methods though their influence on an optimum structure is more difficult to demonstrate. Further research is needed in this area.

Investment analysis incorporating risk in the discount rate is a more explicit way of evaluating private investment options. Higher risk raises the discount rate and reduces the impact of long term events. Tax shelters lower the discount rate with the opposite effect. In agriculture these assumptions change the level of the productive valuations that result from use of such discount rates. There is a case for checking whether pre-tax and post-tax discount rates would alter any **ranking** of possible investment projects.

Risk adjusted discount rates should in theory assist the interpretation of farm purchase decisions. In practice the decision appears to be influenced by a wider set of factors. However, the required equity return model does provide a good rationale for the influence of government policy on land prices and markets.

Option pricing has a complementary role to discounting. OPT will handle cases where discontinuous decision making is involved, where risk levels change in mid stream, and where guarantees build a floor under some price structure. This area of investigation is relatively undeveloped in agricultural economics.

The CAPM offers considerable computational efficiency in risk modelling of whole farms with little loss of accuracy. New Zealand data suggests that comparison of total risk and systematic risk definitions would change to some extent the ranking of enterprises in whole farm risk modelling. The extension applications of the model require further investigation. Farmers may have difficulty with the finer definitions of risk however. Portfolio theory has considerable practical application to farm extension if appropriate models, diagrams and enterprise data can be assembled for a particular locality.

Arbitrage pricing theory is a refinement of CAPM. It offers an alternative to the formulation of a single index of market returns. It is computationally difficult and has not been reported in a farming situation.

Appropriate comparisons of on-farm and off-farm investment incorporating risk criteria are not well developed. The literature is very thin. The risk models discussed in this paper appear to offer considerable scope for further analysis of balanced portfolios which include off-farm investment.

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