The Australian Journal of
Agricultural and
Resource Economics

Journal of the Australian Agricultural and Resource Economics Society

The Australian Journal of Agricultural and Resource Economics, 52, pp. 183–202

Should farmers invest in financial assets as a risk management strategy? Some evidence from New Zealand*

Gilbert Nartea and Paul Webster†

This study explores the potential for risk reduction by New Zealand farmers through the diversification of their farm asset portfolios to include financial investments such as ordinary industrial shares, government bonds and bank bills. Low correlations between rates of return on farm and these financial assets suggest that significant reduction of income variability might follow their inclusion in farmers' portfolios. Stochastic efficiency analysis is used to analyse alternative portfolios of ordinary shares, government bonds and bank bills and New Zealand farmland, using coefficients of absolute risk aversion derived from a negative exponential utility function. The results suggest that those farmers showing high degrees of risk aversion would gain utility by including financial assets in their portfolios. Deregulation of the New Zealand economy in the 1980s appeared to reduce the potential gains from diversification. Bonds rather than ordinary shares are the main contributors to portfolios which maximise utility for individuals classified as 'somewhat' risk averse.

Key words: financial assets, NZ farmland, risk management, stochastic efficiency analysis.

1. Introduction

Several studies have shown that combining farmland with financial assets could reduce the variability of farmers' incomes (Moss *et al*. 1987; Young and Barry 1987; Lins *et al*. 1992; Nartea and Pellegrino 1999; Painter 2000). Yet a survey of farmers and growers in New Zealand (NZ) revealed that their preferred risk management strategies have a predominantly on-farm focus. In order to stabilise their returns, farmers and growers relied mostly on precautionary measures such as spraying and drenching, farm enterprise diversification, and keeping debt levels low. Off-farm financial strategies for reducing risk, such as investment in financial assets were not favoured, perhaps because these were not perceived as particularly efficient strategies for managing risk (Martin 1996). One possible explanation for this is that there is a significant gap between farmer perceptions and the reality of the potential benefits from diversification with financial investments. Another

* We are grateful to Ross Kingwell, the Associate Editor, and three anonymous referees for helpful comments and suggestions that have greatly improved the paper.

† Gilbert Nartea (email: narteag@lincoln.ac.nz) is a Senior Lecturer in Finance, Commerce Division, Lincoln University, New Zealand, and Paul Webster is Professor Emeritus, University of London, UK.

doi: 10.1111/j.1467-8489.2008.00413.x

explanation could be that these benefits are not large enough to entice farmers to sacrifice expected incomes in order to stabilise returns.

There were 60 000 farms in New Zealand in 2004, over a third of which were sheep and beef operations covering approximately two-thirds of the 15.5 million hectares of land under occupation. The agricultural sector, which made up 65 per cent of New Zealand's export earnings, underwent dramatic change from being highly subsidised to a deregulated sector almost overnight. This deregulation which began in 1984 and was largely completed in 1988, exposed producers to world market competition resulting in increased technical efficiency (Kalaitzandonakes and Bredahl 1994; Paul *et al*. 2000), though it had undoubtedly increased their exposure to risk (Tyler and Lattimore 1990).

The purpose of this paper is to investigate the benefits of using financial investments as a possible risk management strategy for NZ sheep and beef farmers. Our approach is to use data for the distribution of returns of different asset classes derived from historic sources. While we clearly cannot predict what *ought* to be the components of optimal portfolios in the future, we take the view that a historical approach might provide some clues as to the possible benefits foregone in the past and thus point to avenues of investigation in the future. We start with a mean-variance (EV) analysis in order to quantify the possible risk-reduction benefits of moving from farm assets alone to an investment portfolio of farm and financial assets. We then turn to the question of whether the benefits are sufficient to persuade farmers to switch investments in the light of their own attitudes to risk. The analysis is carried out for the two periods before and after deregulation with the aim of investigating the effect of the change in investment climate. Because of data restrictions, this first stage includes only shares as an alternative asset. Bonds and bank bills are included in the analysis presented in a later section of the paper.

2. Background

A number of studies have investigated the desirability of combining farmland investments with financial assets. Barry (1980), Kaplan (1985), Young and Barry (1987) and Lins *et al*. (1992) all found that US farmland's high return and low correlation with US stocks and bonds made it an attractive asset for investors interested in diversification. Moss *et al*. (1987), in a similar US study, found that portfolios they defined as risk efficient contained 30–68 per cent farmland. In Canada, Painter (2000) also found that Saskatchewan farmland returns were negatively correlated with the returns from financial assets and that there was thus scope for the reduction of income variability.

In New Zealand, studies attempting to partition risk into diversifiable and non-diversifiable components within the context of the capital asset pricing model indicate that as much as 70 per cent of the total risk in sheep and beef farming and 76 per cent in dairy farming could be eliminated by diversifying their operations (Narayan and Johnson 1992; Nartea and Pellegrino 1997;

Nartea and Dhungana 1998). Dairy farm returns were also negatively correlated with bond yields and weakly positively correlated with share returns, while sheep and beef farm returns were negatively correlated with share returns suggesting that farmers should look towards diversifying into financial assets (Nartea and Dhungana 1998; Nartea and Pellegrino 1999).

Risk, of course, is in the eye of the beholder. While the above studies have generally shown that simple measures of volatility such as variance or the coefficient of variation can be reduced by diversifying, it is another question as to whether individual farmers will accept the consequent changes in other measures such as expected income. Our purpose therefore is to use an expected utility approach to see whether New Zealand farmers' attitudes to risk would be likely to influence their choices when it comes to possible investments in financial assets.

3. Model

The first stage of the analysis is to identify candidate portfolios of farmland and financial assets. We find these alternative combinations using expected value-variance (EV) analysis (Markowitz 1952). This provides a set of EV-efficient portfolios which are combinations of assets that minimise the risk levels (measured as variance or standard deviation) for desired expected rates of return. Such portfolios can be generated by solving the following quadratic formulation:

$$\text{Min}\,\sigma_p = (\Sigma\Sigma\, x_i \sigma_{ij} x_j)^{0.5} \tag{1}$$

subject to

$$\Sigma\, x_i E(r_i) \geq Z \tag{2}$$

$$\Sigma\, x_i = 1 \tag{3}$$

where σ_p is the portfolio standard deviation, x_i is the proportion of asset i in the portfolio, $E(r_i)$ is the expected return of asset i, σ_{ij} is the covariance between assets i and j (variance of asset i if $i = j$), and Z is the expected portfolio return, which is varied parametrically to obtain the EV-efficient set. We start by investigating the risk-reduction possibilities of these portfolios by observing the changes in some simple measures of volatility.

But the utility maximising investor will choose that portfolio which has, for him or her, the highest certainty equivalent CE. One approach is to use the EV framework to generate certainty equivalents based on the assumption that the decision-maker reflects a quadratic utility function in his or her choices, where

$$CE = Z - \frac{1}{2} A \sigma^2 \tag{4}$$

and for any given level of certainty equivalent

$$A = 2\frac{dZ}{d\sigma^2} \tag{5}$$

where A is the coefficient of absolute risk aversion (e.g. Newbery and Stiglitz 1977). But the assumption that a quadratic utility function actually describes the preferences of decision-makers suffers from a number of well-known difficulties, such as the assumption of increasing absolute risk aversion. More recently Hardaker *et al.* (2004a) have shown how the complete distribution of any given risky prospect may be used with more plausible utility functions, such as the negative exponential, in the application of stochastic efficiency analysis (e.g. stochastic efficiency with respect to a function, SERF). In the negative exponential case, the certainty equivalent of a portfolio can be found as follows:

$$CE = \ln\left\{\left[\frac{1}{n}\sum \exp(-Aw_i)\right]^{-1/A}\right\} \tag{6}$$

where w_i is the ith of n random observations of outcomes of the risky portfolio, and A is the coefficient of absolute risk aversion.

Critical levels of A at which the utility maximising portfolios change can then be compared with what is known about the risk preferences of New Zealand farmers. Thus judgements can be made as to whether the holding of financial assets might have been a useful strategy for managing income risk in the periods under study.

4. Data

Time series data relating to annual rates of return on shares, bonds, bank bills and farmland were obtained for the period 1966–2005. Annual rates of return were calculated as the sum of the current return and the capital gain (Sharpe *et al.* 1999) expressed as:

$$R_{it} = [D_{i1} + (V_{i1} - V_{i0})]/V_{i0} \tag{7}$$

where R_{it} is the total rate of return in year t for the ith asset, D_{i1} is the current return, V_{i0} is the asset value at the beginning of each year, and V_{i1} represents the asset value at the end of the year.

We make no distinction between realised and unrealised capital gains. We argue that retaining the asset (and earning only 'unrealised' capital gain) is no different from selling it at year end, 'realising' the capital gain, and immediately reinvesting by buying the asset back. This approach is common in the literature involving farmland (Young and Barry 1987; Painter 2000). We suggest that though the capital gain component may be difficult to realise, farmers often consider it as an important component of farmland's total return. The view is taken that farmland's illiquidity is an additional dimension to its total risk that should be compensated if it cannot be diversified. Nevertheless, the issue of comparative asset liquidity with respect to land and financial assets does raise concerns to which we return to later in the paper.

4.1 Ordinary shares, government bonds and Bank bills

Ordinary shares were represented by the New Zealand Market Index as calculated by DataStream for the period 1990–2005, and by the New Zealand Stock Exchange NZSE40 Capital Index for the period 1966–2003. This index covers 40 of the largest and most liquid shares weighted according to their market capitalisation. The Capital Index, however, measures only the capital value of the securities. DataStream also reports the NZSE 40 Gross index from 1992–2003 from which we determined the dividend yield by comparing it with the NZSE 40 Capital Index over the same period. In the absence of other sources of dividend information, the average dividend yield over the 1992–2003 period, 6.65 per cent, was assumed to apply over the period 1966–1991. We recognise that in so doing, one source of variability will have been lost, but in the absence of other information about Capital Index dividends there were felt to be few alternatives to this procedure.

Bond rates of return were also available from DataStream for the period 1990–2005. Short-term bonds refer to the two-year government bond index, medium-term bonds refer to the five-year government bond index, and the ALL bond index refers to the ALL lives government bond index. Except for the ALL lives government bond index, DataStream benchmark indices are based on a single bond deemed to be the most representative. Generally, the benchmark bond is taken as the most recent issue with the specified term to maturity. The 30- and 90-day bank bill rates of return for the period 1990–2005 refer, respectively, to the NZX 30 and NZX 90 bank bill indices. Because of these data limitations, the initial analysis (sections 5.1 and 5.2) adds only ordinary shares to the portfolio, while bonds and bills are introduced later (section 5.3).

4.2 Sheep and beef grazing farmland

Rates of return from farmland were taken from the New Zealand Sheep and Beef Farm Survey (New Zealand Meat and Wool Board Economic Service various dates). A sheep and beef farm was defined as a privately operated farm with at least 80 per cent of the stock units in sheep and/or beef cattle and at least 70 per cent of the farm revenue being derived from sheep or sheep and beef cattle.

The yearly total farmland rate of return was taken as the sum of the production rate of return and the capital gain. The production rate of return from farmland was the weighted average rate of return on assets for all classes of sheep and beef farms in the Survey which involves roughly 500–550 farms per year in total. The production rate of return for an individual farm within the Survey was represented by the economic farm surplus divided by total farm capital. The economic farm surplus was defined as the net income before interest, rent, and taxes, less an imputed managerial reward.

The capital gain component was represented by the annual percentage change in the grazing land price index (Valuation New Zealand various dates).

5. Results

5.1 Comparative risk and return measures

Figure 1 shows the overall pattern of returns from farmland and ordinary shares over the period 1966–2003. The discontinuity associated with the deregulation of the New Zealand economy in the 1980s is immediately apparent. The process and effects of deregulation have been well described elsewhere (Frengley and Engelbrecht 1998; Paul *et al*. 2000) but suffice it to say that the investment climate changed considerably. We therefore based our initial analysis on the risk characteristics of assets before and after deregulation. As well as investigating whether farmers' portfolios should perhaps have included financial assets given the post-deregulation situation, the question was also 'did the change in the investment climate brought about by deregulation warrant a modification in farmers' asset allocation?'.

The process of deregulation began in 1984 and was largely completed by 1988; hence we took the period from 1966 to 1983 as the pre-deregulation period and 1988–2003 as the post-deregulation period. In common with

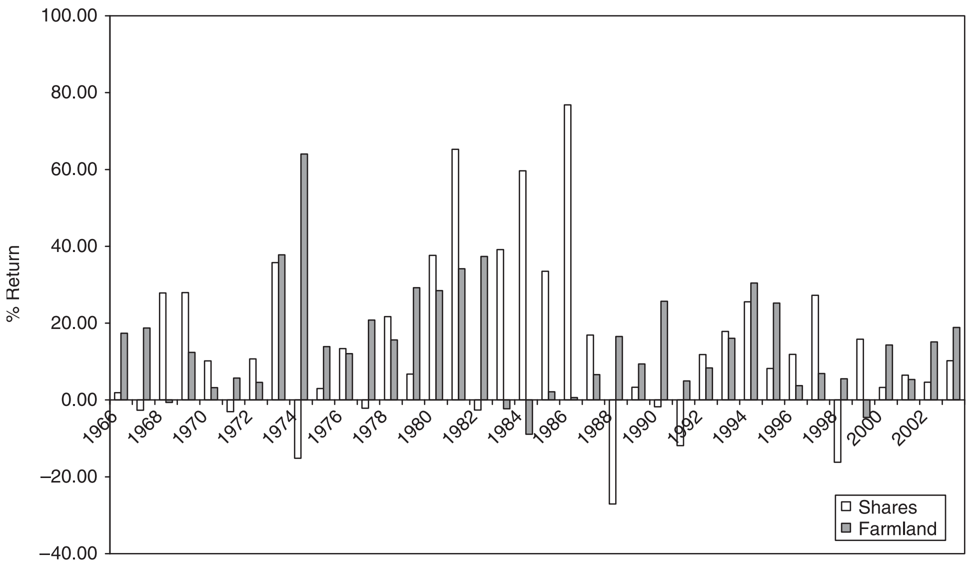

Figure 1 Annual returns from farmland and shares, 1966–2003.

other workers in this area (e.g. Young and Barry 1987; Fletcher and Marshall 2005), we use nominal values. Since all classes of assets are assumed to be subject to similar levels of inflation within a year, the relationships between their risk and return characteristics remain unchanged whether nominal or real values are used as the basis for comparison.

Table 1 shows that the mean and variability of farmland and share returns both decreased in the post-deregulation period. Farmland outperformed shares in both periods, earning a higher expected rate of return at a lower level of variability. However while the relative variability (as measured by the coefficient of variation, CV) of farmland returns appears to have decreased in this period, that of shares increased. This is perhaps unsurprising given that the pre-deregulation period included years of turbulence in the international economy caused by events such as the oil price shocks of the 1970s. Also noteworthy is the change in the covariability of farmland and share returns. Farmland and share returns were negatively correlated before deregulation but became slightly positively correlated after deregulation. A t-test however, indicated that both correlation coefficients were not significantly different from zero. We discount the possibility that the positive correlation could be due to agribusiness companies dominating the NZ stock market index as agriculture-related firms only comprised around 8 per cent of the total market capitalisation the index over the period.

While the raw values of these correlation coefficients suggest that potential benefits from diversification could have been higher in the pre-deregulation period, we now investigate the possible level of such benefits in both periods.

5.2 Potential gains from diversification

To quantify the gains from diversification, we generated 10 EV-efficient portfolios of farmland and shares for each of the two periods by solving Equation (1) subject to Equations (2) and (3) for alternative values of Z, using the program 'The Investment Portfolio', version 2.5 (Elton *et al*. 2007). Pre-deregulation period results are shown in Table 2 and post-deregulation period results are shown in Table 3. The portfolios include the minimum variance portfolio (MVP) as well as the maximum expected return portfolio (MRP). It is evident that farmland dominates both sets of portfolios. Pre-deregulation period results show an MVP (Portfolio 1) that consists of 58.5 per cent farmland and the rest in shares with an expected return of 17.8 per cent and a standard deviation of that return of 11.94 per cent. Post-deregulation period results show an MVP (Portfolio 1) that consists of 71.8 per cent farmland and the rest in shares with an expected return of 10.64 per cent and a standard deviation of that return of 8.11 per cent. Higher returns are obtained by increasing the proportion of farmland while decreasing the proportion of shares. Portfolio 10 is the MRP and consists only of farmland in both cases.

Tables 2 and 3 also show statistics relating to the potential for risk reduction of diversified portfolios. Thus pre-deregulation (Table 2), investing in Portfolio 8

Table 1 Risk and return measures for farmland and ordinary shares, pre- and post-deregulation

	Pre-deregulation 1966–1983			Post-deregulation 1988–1903		
	Production return	Capital gain	Total return	Production return	Capital gain	Total return
Farmland						
Expected return (%)	3.95	15.64	19.59	2.76	9.83	12.62
Standard deviation (%)	1.70	16.42	16.71	1.45	9.14	9.38
CV	0.43	1.05	0.85	0.53	0.93	0.74
Ordinary shares						
Expected return (%)			15.31			5.59
Standard deviation (%)			20.30			14.48
Coefficient of variation (%)			1.33			2.59
Correlation total farmland return and ordinary share return			–0.14			+0.07

Table 2 Pre-deregulation portfolios, 1966–1983

	Portfolio									
	1*	2	3	4	5	6	7	8	9	10†
Composition of portfolio (%):										
Farmland	58.5	60.0	65.0	70.0	75.0	80.0	85.0	90.0	95.0	100.0
Ordinary Shares	41.5	40.0	35.0	30.0	25.0	20.0	15.0	10.0	5.0	0.0
Expected return (%)	17.81	17.88	18.09	18.30	18.52	18.73	18.95	19.16	19.37	19.59
Standard deviation of return (%)	11.94	11.95	12.09	12.38	12.82	13.39	14.09	14.88	15.76	16.71
Coefficient of variation (%)	67.1	66.9	66.8	67.6	69.2	71.5	74.3	77.6	81.3	85.3
Reduction in expected return (%)‡	9.1	8.7	7.6	6.6	5.5	4.4	3.3	2.2	1.1	–
Reduction in relative variability (%)§	21.4	21.6	21.7	20.7	18.8	16.2	12.8	9.0	4.6	–
Critical value of A (Quadratic)¶	0.0006787	0.0001334	0.0000598	0.0000385	0.0000284	0.0000225	0.0000186	0.0000159	0.0000138	0.000
Critical value of A (Negative exponential)**	–	–	0.0000816	0.0000501	0.0000367	0.0000285	0.0000234	0.0000197	0.0000171	0.000
Category of risk averter††			Somewhat, rather, very, extremely			Hardly				

*Minimum variance portfolio (MVP).
†Maximum expected return portfolio.
‡Percentage change in the expected return relative to Portfolio 10.
§Percentage change in the coefficient of variation relative to Portfolio 10.
¶Using Equation (5), $A^* = 2(Y_{10} - Y_9)/(\sigma^2_{10} - \sigma^2_9)$ where $Y_{10} = Z_{10}{*}w$; Z_{10} is the rate of return of portfolio 10, etc., and w is wealth (NZ$100 000).
**Using Equation (6) in the SERF spreadsheet.
††Allocated by comparing values of A in Table 4 with the critical values of A (Negative exponential).

Table 3 Post-deregulation portfolios, 1988–2003

	Portfolio									
	1*	2	3	4	5	6	7	8	9	10†
Composition of portfolio (%)										
Farmland	71.8	74.0	76.0	78.0	80.0	82.0	85.0	90.0	95.0	100.0
Ordinary shares	28.2	26.0	24.0	22.0	20.0	18.0	15.0	10.0	5.0	0.0
Expected return (%)	10.64	10.79	10.93	11.07	11.21	11.35	11.56	11.92	12.27	12.62
Standard deviation of return (%)	8.11	8.12	8.14	8.18	8.23	8.29	8.41	8.66	8.99	9.38
Coefficient of variation (%)	76.2	75.2	74.5	73.8	73.4	73.0	72.7	72.7	73.3	74.3
Reduction in expected return (%)‡	15.7	14.5	13.4	12.3	11.1	10.0	8.4	5.6	2.8	
Reduction in relative variability (%)§	–2.6	–1.2	–0.2	0.7	1.3	1.8	2.2	2.2	1.4	
Critical value of A (Quadratic)¶	0.0022498	0.0007819	0.0004822	0.0003486	0.0002730	0.0002147	0.0001601	0.0001214	0.0000978	0.000
Critical value of A (Negative exponential)**	–	–	0.0011230	0.0004795	0.0003200	0.0002280	0.0001603	0.0001189	0.0000955	0.000
Category of risk averter††					Very, extremely	Rather				Hardly, somewhat

Notes *–†† as per Table 2.

as compared with Portfolio 10 could be said to reduce relative variability (coefficient of variation) by 9.0 per cent while reducing expected return by only 2.2 per cent. Compared with holding sheep and beef farm assets alone, the EV-efficient portfolios showed possible reductions in relative variability of up to 21.4 per cent for a loss in expected return of only 9.1 per cent. There would thus appear to have been significant potential for income stabilisation by the inclusion of ordinary shares in farmers' portfolios in the period before deregulation.

In the post-deregulation period (Table 3), the situation was somewhat different. Investing in portfolio 8 reduced expected return by 5.6 per cent but only reduced relative variability by 2.2 per cent. Though there were still apparent benefits from diversification after deregulation, the level of such benefits was considerably lower as compared with the pre-deregulation period.

It was noteworthy that, while standard deviation of returns declined continuously as one would have expected, the coefficient of variation started to increase below portfolio 4. This phenomenon underlines the dangers of mixed messages arising from the use of apparently simple measures of volatility in risky decision-making.

5.3 Would New Zealand farmers actually choose to diversify?

While the above results suggest that there were potential gains from diversification, the question now arises as to whether such benefits would have outweighed the costs of expected return forgone, in terms of the manager's utility. This question can only be answered by relating these results to the attitudes to risk of the individual decision-maker.

In the absence of such detailed information, we calculated the critical values of the coefficient of absolute risk aversion, A, just needed to maximise utility for each portfolio. We took each selected portfolio and used its historical returns to define an income distribution based on an assumed wealth of NZ$100 000. The complete distribution was used with Equation (6) in a modified SERF spreadsheet (Hardaker *et al.* 2004b, table A1) which incorporated the negative exponential form of utility function.

While for the reasons given above, the negative exponential is preferred we also report the quadratic results using Equation (5). Both sets of coefficients are reported in the lower sections of Tables 2 and 3.

Thus in the pre-deregulation period shown in Table 2, the risk indifferent manager, or one for whom $0 \leq A \leq 0.0000171$, would have chosen portfolio 10, and a manager for whom $0.0000171 \leq A \leq 0.0000197$ would choose portfolio 9 and so on until portfolio 3 which would only have been chosen by a manager whose coefficient of absolute risk aversion was 0.0000816 or greater. The quadratic estimates of A are reassuringly within the same orders of magnitude as those of the negative exponential. In the post-deregulation situation, the critical A values have to be considerably higher before the switch is made from the maximum return all-farmland portfolio 10. Indeed the $A = 0.0000955$ needed to shift to portfolio 9 in the post-deregulation period is greater than the $A = 0.0000816$ at which the pre-deregulation manager would have moved to portfolio 3 as above. This is consistent with the results reported in the previous section where it was suggested that there were fewer benefits to be gained by diversifying into shares in the post-deregulation setting. In other words only managers who were relatively more risk averse would have chosen diversified portfolios in the post-deregulation period as compared with the pre-deregulation period.

In passing it is worth noting that portfolio 3 dominates portfolios 1 and 2 under SERF for all non-negative certainty equivalents in both Tables 2 and 3. This contrasts with the situation under quadratic utility where portfolios 1 and 2 lie on the EV-efficient boundary, thus demonstrating the divergence of utility based on the complete distribution plus a negative exponential form as compared with utility based on the quadratic form.

We now turn to the question of the levels of risk aversion among New Zealand farmers. The coefficient of absolute risk aversion for individual farmers or for groups of farmers has been estimated using a number of frameworks and in a variety of situations. Saha *et al.* (1994) reviewed a number of studies which showed very variable results. Thornton (1985) has provided one of the few examples of the empirical estimation of the risk attitudes of New Zealand farmers. In his sample of 12 cereal growers he found four who showed risk indifference or slight risk preference (i.e. $A \geq 0$) and eight who showed varying degrees of risk aversion. Unfortunately his observations related to NZ dollar outcomes for bets involving gross margins of 10 hectare crops of barley rather than total farm income and so his estimates of absolute risk aversion coefficients were considered inappropriate for our purposes.

Alternatively, Hardaker *et al.* (2004b) have suggested a typology for a range of values for the coefficient of relative risk aversion of wealth, R, of between 0.5 ('hardly risk averse') and 4 ('extremely risk averse') with a typical value of 1 ('somewhat risk averse'). Assuming that the coefficient of relative risk aversion for 'permanent' income also follows these values, they also show how coefficients of absolute risk aversion for permanent income y may be estimated, since

$$A = R/y \tag{8}$$

and

$$y = Z \cdot w \tag{9}$$

where Z is the portfolio expected return and w is wealth (Hardaker *et al.* p. 109 *et seq.*). The first two columns of Table 4 shows sets of A calculated for the pre- and post-deregulation situations. Permanent income was set at a level which approximates the level of expected income faced by the range of risk averse categories under each situation (for our purposes, set at the expected return produced by portfolio 6 in each situation) and wealth was set at NZ$100 000.

Table 4 Coefficient of risk aversion for various categories of decision-maker

		Coefficients of absolute risk aversion†, A		
Category of decision-maker*	R	Pre-deregulation (see Table 2)	Post-deregulation (see Table 3)	1990–2005 data (see Table 7)
Hardly risk averse at all	0.5	0.0000267	0.0000441	0.0000372
Somewhat risk averse	1	0.0000534	0.0000881	0.0000744
Rather risk averse	2	0.0001068	0.0001762	0.0001488
Very risk averse	3	0.0001602	0.0002643	0.0002232
Extremely risk averse	4	0.0002136	0.0003524	0.0002976
Expected return (portfolio 6), Z (%)		18.73	11.35	13.44

Notes: *see Hardaker *et al*. (2004b), p. 109. R is the coefficient of relative risk aversion for wealth.
†$A = R/y$ where $y = Z{\cdot}w$ Z is expected portfolio return and w is wealth, set at NZ$100 000.

Thus a person who is ‘hardly’ risk averse ($A = 0.0000267$) would have chosen to diversify towards portfolio 6 with 20 per cent of his assets in shares in the pre-deregulation period shown in Table 2, with his more risk averse colleagues moving to 35 per cent in shares (Table 2, final row). However, the results are different in the post-deregulation period. Table 3 shows that both our ‘hardly’ and our ‘somewhat’ risk averse farmers would not have gained utility by shifting away from the maximum expected income portfolio 10. Only their more risk averse colleagues would benefit by diversifying in the changed circumstances, moving to between 15 and 20 per cent diversification into shares.

While our analysis has had to proceed on the basis of a conjectured typology of risk aversion and without any direct knowledge of the frequencies of occurrence of the various categories of risk aversion within the population of New Zealand farmers, we conclude that there have been opportunities for income stabilisation by diversifying into financial assets. Furthermore the more risk averse farmers might have gained utility by doing so.

These results are interesting given the relatively high CV (74 per cent) of farmland returns and the results of some past studies suggesting that CV’s can be reduced by diversifying with financial assets. For instance, Young and Barry (1987) who found a similar coefficient of variation (84.5 per cent) for Illinois grain farms suggested that including up to 25 per cent financial assets in the portfolio could reduce relative variability by 15–25 per cent. In a more recent study, Painter (2000) found a significantly higher coefficient of variation (151 per cent) for Saskatchewan grain farms and also suggested the inclusion of financial assets in a farmer’s investment portfolio. But neither of these studies took an expected utility approach.

5.4 Introducing government bonds and bank bills into the analysis

We now investigate whether the same results apply if other financial assets are introduced into the analysis. A new set of series was constructed because

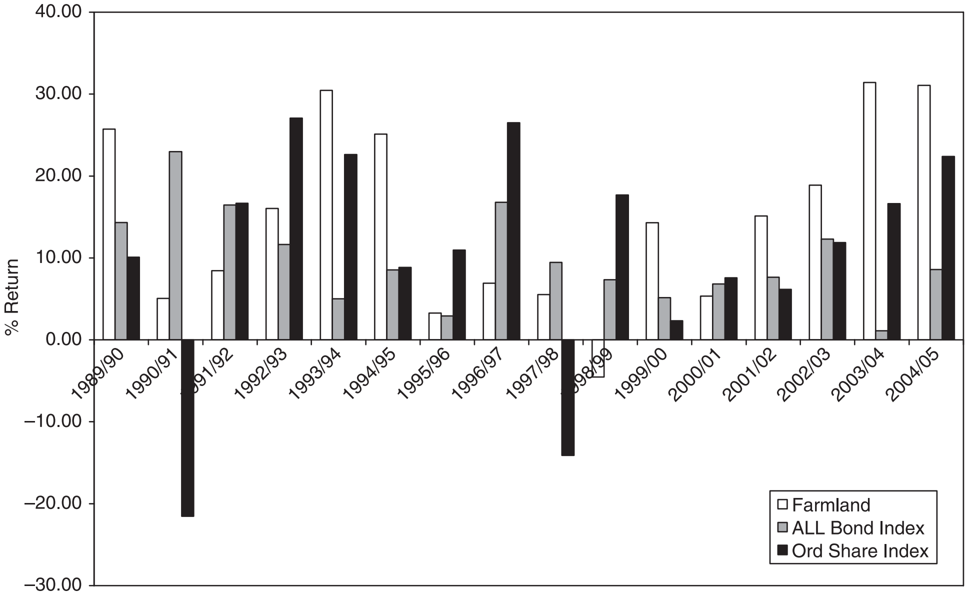

Figure 2 Returns from farmland, ordinary shares and bonds, 1990–2005.

complete data on bond and bank bill rates of return were unavailable for the periods analysed earlier. In addition, returns from ordinary shares were taken from the DataStream Total Market Index since the NZSE 40 Capital Index used earlier was available only up to 2003. Figure 2 illustrates the relationships between the rates of return from farmland, shares and bonds over the period 1990–2005.

Table 5 shows risk and return measures for farmland, shares, bonds and bank bills and reveals that farmland again outperformed ordinary shares, bonds and bank bills over 1990–2005. While share returns outperformed

Table 5 Risk and return measures for farmland and NZ financial assets, 1990–2005

	Mean annual rate of return* (%)	Standard deviation (%)	Coefficient of variation (%)
Farmland			
Production return	2.30	1.23	0.54
Capital gain	12.58	11.33	0.90
Total return	14.88	11.28	0.76
Ordinary shares	10.73	13.35	1.24
ALL bonds	9.82	5.70	0.58
30-day Bank-bill	7.87	2.80	0.36
90-day Bank-bill	7.90	2.76	0.35
Short-term bonds	8.38	3.66	0.44
Medium-term bonds	9.68	6.14	0.63

*All figures in nominal terms.

Table 6 Correlation of farmland and financial asset returns, 1990–2005

	Farmland	Shares	ALL bonds	30-day T-bill	90-day T-bill	Short-term bonds	Medium-term bonds
Farmland	1.00						
Ordinary shares	0.33	1.00					
ALL bonds	–0.27	–0.28	1.00				
30-day T-bill	–0.11	–0.44	0.66	1.00			
90-day T-bill	–0.14	–0.44	0.69	1.00	1.00		
Short-term bonds	–0.37	–0.29	0.90	0.73	0.77	1.00	
Medium-term bonds	–0.27	–0.26	0.99	0.67	0.71	0.94	1.00

both bonds and bank bills, shares were up to twice as volatile as bond returns and 1.5 times more volatile than farmland returns on a CV basis.

The correlation coefficients between the return on farmland and financial assets are shown in Table 6. Farmland returns were negatively correlated with bond and bank bill yields and moderately positively correlated with share returns. This suggests that substantial risk reduction could be obtained by including bonds in the portfolio.

Again we generated 10 risk efficient portfolios using The Investment Portfolio version 2.5. Table 7 shows the composition and risk-return characteristics of these portfolios. The bonds made a significant contribution to risk reduction with ordinary shares and bills featuring in the much less risky portfolios. There appear to have been good possibilities for trading risk for return in this period. An investment portfolio made up of 5 per cent bonds and 95 per cent farmland (Portfolio 8) would have reduced relative variability of returns by 4 per cent but also reduce expected returns by only 1.7 per cent.

When the typology of risk averters is included, we now find that the 'hardly' risk averse farmer remains at the MRP, but his more risk averse colleagues would all have chosen diversified portfolios involving bonds and increasingly small proportions of their assets in farmland. Note that the 'somewhat' risk averse farmer would have chosen the MRP in Table 3, but when bonds are made available in Table 4, he would have moved to a diversified portfolio including bonds. Thus bonds are the main means of reducing income variability in these portfolios. This confirms the propensity of the more risk averse farmers to diversify, but the introduction of bonds into the analysis suggests that they will do it using bonds (rather than shares).

Figure 3 further explores these relationships by displaying the certainty equivalents (CE) achieved by the 10 portfolios for the five risk aversion categories. The 'risk indifferent' line indicates the expected income levels. It is thus possible to observe what each category might forgo in CE terms by moving (or not) to alternative portfolios. For example, while the 'somewhat' risk averse category maximises CE at portfolio 5, only a small amount of CE appears to be forgone as compared with portfolio 10. The question then

Table 7 Portfolios including bonds, 1990–2005

	Portfolio									
	1*	2	3	4	5	6	7	8	9	10†
Composition (%)										
Farmland	3.0	12.1	19.8	26.2	42.3	71.5	90.0	95.0	97.5	100.0
Ordinary shares	9.8	7.9	6.7	6.2	3.7	0.0	0.0	0.0	0.0	0.0
ALL bonds	0.0	0.0	7.9	22.9	54.0	28.5	10.0	5.0	2.5	0.0
30-day bank-bill	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
90-day bank-bill	87.2	50.6	22.3	1.4	0.0	0.0	0.0	0.0	0.0	0.0
Short-term bonds	0.0	29.4	43.3	43.3	0.0	0.0	0.0	0.0	0.0	0.0
Medium-term bonds	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Expected return (%)	8.39	9.11	9.83	10.55	11.99	13.44	14.38	14.63	14.76	14.88
Standard deviation of return	2.22	2.41	2.88	3.49	5.04	7.79	10.01	10.64	10.96	11.28
Coefficient of variation (%)	26.5	26.4	29.3	33.1	42.0	58.0	69.7	72.7	74.3	75.8
Reduction in expected return (%)‡	43.6	38.8	34.0	29.1	19.4	9.7	3.4	1.7	0.9	0.0
Reduction in relative variability (%)§	65.0	65.2	61.4	56.4	44.6	23.5	8.1	4.0	2.0	0.0
Critical value of A (Quadratic)¶	0.0017166	0.0005767	0.0003714	0.0002184	0.0000819	0.0000474	0.0000391	0.0000370	0.0000357	0.000
Critical value of A (Negative exponential)**	–	0.0007490	0.0003900	0.0002090	0.0000933	0.0000559	0.0000461	0.0000436	0.0000420	0.000
Category of risk averter††			Very, extremely	Rather	Somewhat					Hardly

Notes *–†† as per Table 2.

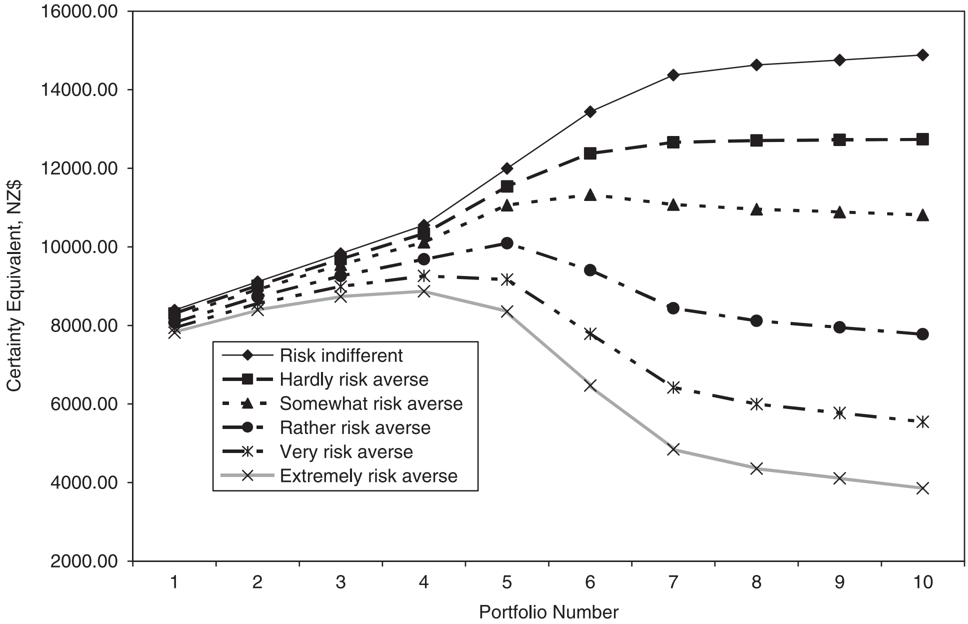

Figure 3 Portfolio certainty equivalents for risk aversion categories, 1990–2005 data.

arises as to whether the transaction and intellectual investment costs would be greater than the benefits of the diversification in this case. However it is clear that the ‘rather’, ‘very’ and ‘extremely’ risk averse categories would lose considerable amounts of CE by not diversifying.

6. Discussion and conclusion

Our analysis suggests that there have been possibilities for income stabilisation in New Zealand farming via the use of financial assets and furthermore that farmers could have increased their utility by adopting such strategies. The data also suggests that the deregulation of the New Zealand economy had some effect on those optimal choices. But many points of caution need to be made.

First, we have considered only the purchase of financial assets as alternative investments to farmland and ignored transactions costs involved in portfolio restructuring. Nonetheless, a cash-poor asset-rich farming enterprise may be inhibited from purchasing financial assets for risk reduction purposes. We also recognise that there are many other possibilities for asset diversification such as real estate in the local town, rural tourism ventures as well as the use of commodity derivatives. Such alternatives must await further research.

Second, a more complete analysis would include simultaneous solution of the optimal cropping and stocking pattern with the investment portfolio decision. Our approach thus ignored any potential for adjustment of the pattern to contribute toward optimal income risk management. But such an approach would need data series relating to the risks of individual cropping and stocking alternatives which are not at present available.

Third, the use of an expected utility framework for farmland investment decisions may seem unduly restrictive given the developments in other approaches such as prospect theory (Kahneman and Tversky 2000). But a difficulty is that many of these approaches remain to be operationalised in ways which allow direct numerical comparison of alternatives.

Fourth, and more technically, we used EV analysis to define the candidate portfolios followed by stochastic efficiency analysis (SERF) to determine the certainty equivalents of those portfolios. It is at least theoretically possible that the biases introduced by using the EV framework led to some SERF-efficient portfolios being ignored. However, because the distributions were found to be approximately normal, this was not thought to be a major source of error. Nevertheless, it was noted earlier that some EV-efficient portfolios were SERF-dominated by others.

Fifth, it may be that the use of group averages to generate the estimates of farmland income variability leads to underestimation of that variability. The importance of the point is highlighted by Just (2003) who suggested that aggregate US crop yield data underestimated the farm level variance by between two and 10 times. We would argue that New Zealand represents a rather less heterogenous environment for crop and stock farm incomes as compared with crop yields across the whole of the US. However the general point remains but if anything, it perhaps strengthens the case for diversification made here.

Sixth, it should be remembered that our analysis is based on historic data and that past investment performance is not a guide to future returns. Situations change and as our pre and post-deregulation analysis has shown, risk relationships change. Decisions must be made on anticipated costs and benefits.

Finally, the arbitrary nature of the classes of risk averter should be borne in mind. Given the apparent precision of the coefficients of absolute risk aversion seen in Table 4, it would have been possible to identify for each class the exact utility-maximising portfolio lying between those already identified. However the critical value approach with the identified portfolios was preferred since it presented a simpler basis for comparisons. While the results relating to the less risk-averse categories appear plausible, those relating to more risk averse categories appear less so. It seems unlikely that someone who was ‘extremely’ risk averse would even remain as a manager in an industry such as agriculture. Until we know more about the risk taking characteristics of the generality of New Zealand farmers, it is difficult to be certain about how widespread the uptake of risk reducing measures might be.

References

Barry, P.J. (1980). Capital asset pricing and farm real estate, *American Journal of Agricultural Economics* 62, 549–553.

Elton, E., Gruber, M. and Blake, C. (2007). *The Investment Portfolio*, Version 2.5. Intellipro, Piscataway, NJ.
Fletcher, J. and Marshall, A. (2005). An empirical examination of the benefits of international diversification, *International Financial Markets, Institutions and Money* 15, 455–468.
Frengley, G.A. and Engelbrecht, R. (1998). Economic deregulation and the adjustment of New Zealand farmers. *Choices* 1st Quarter, 1998, 14–19.
Hardaker, J.B., Richardson, J.W., Lien, G. and Schumann, K.D. (2004a). Stochastic efficiency analysis with risk aversion bounds: a simplified approach, *Australian Journal of Agricultural and Resource Economics* 48, 253–270.
Hardaker, J.B., Huirne, R.B.M., Anderson, J.R. and Lien, G. (2004b). *Coping with Risk in Agriculture*, 2nd edn. CAB International, Wallingford.
Just, R.E. (2003). Risk research in agricultural economics: opportunities and challenges for the next twenty-five years. *Agricultural Systems* 75, 123–159.
Kahneman, D. and Tversky, A. (eds) (2000). *Choices, Values and Frames*. Cambridge University Press, New York, USA.
Kalaitzandonakes, N.G. and Bredahl, M.E. (1994). Protectionism, efficiency and productivity growth, in Hartmann, M, Schmitz, P.M. and von Witzke, H. (eds), *Agricultural Trade and Economic Integration in Europe and in North America*. Wissenschaftsverlag Vauk Kiel KG.
Kaplan, H.M. (1985). Farmland as a portfolio investment, *Journal of Portfolio Management* 11, 73–79.
Lins, D., Kowalski, A. and Hoffman, C. (1992). Institutional investment diversification: foreign stocks vs. U.S. farmland, Proceedings of Regional Research Committee NC-161, Department of Agricultural Economics, Kansas State University, Manhattan, Kansas.
Markowitz, H.M. (1952). Portfolio selection, *Journal of Finance* 12, 77–91.
Martin, S. (1996). Risk management strategies in New Zealand agriculture and horticulture, *Review of Marketing and Agricultural Economics* 64, 31–44.
Moss, C.B., Featherstone, M. and Baker, T.G. (1987). Agricultural assets in an efficient multiperiod investment portfolio, *Agricultural Finance Review* 47, 82–94.
Narayan, P. and Johnson, R.W.M. (1992). *Diversifying risk on New Zealand sheep and beef farms*, MAF Policy Conference Papers in Agricultural Economics, Wellington, 105–114.
Nartea, G.V. and Dhungana, B.R. (1998). *Diversifiable and nondiversifiable risk in New Zealand dairy farming*, Proceedings of the NZ Farm Management Society Annual Conference; 18–20 Nov 1998, Waikato University, Hamilton, pp. 172–182.
Nartea, G.V. and Pellegrino, J.M. (1997). *Risk-return characteristics of farmland and their implication for land valuation*, Proceedings of the NZ Farm Management Society Annual Conference; 19–21 Nov 1997, Massey University, Palmerston North, pp. 165–172.
Nartea, G.V. and Pellegrino, J.M. (1999). *Off-farm investment in financial assets as a risk response for New Zealand sheep and beef farms*, Research Report 99/07, Farm and Horticultural Management Group, Division of Applied Management and Computing, Lincoln University.
New Zealand Meat and Wool Board Economic Service (various dates). *The New Zealand Sheep and Beef Farm Survey*. Wellington. Selected issues.
Newbery, D.M. and Stiglitz, J.E. (1977). *The Theory of Commodity Price Stabilization*. Oxford University Press.
Painter, M.J. (2000). Should Saskatchewan farmland be part of your investment portfolio? *Canadian Journal of Agricultural Economics* 48, 39–50.
Paul, C.J., Johnston, W.E. and Frengley, G.A. (2000). Efficiency in New Zealand Sheep and Beef farming: The impacts of regulatory reform, *Review of Economics and Statistics* 82, 325–337.
Saha, A., Shumway, C.R. and Talpaz, H. (1994). Joint estimation of risk preference structure and technology using expo-power utility, *American Journal of Agricultural Economics* 76, 173–184.
Sharpe, W.F., Alexander, G.J. and Bailey, J.V. (1999). *Investments*, 6th edn. Prentice Hall, New Jersey.

Thornton, P.K. (1985). Treatment of risk in a crop protection information system, *Journal of Agricultural Economics* 36, 201–209.
Tyler, L. and Lattimore, R. (1990). Assistance to agriculture, in Sandrey, R. and Reynolds, R. (eds), *Farming without Subsidies*. MAF, G.P. Books.
Valuation New Zealand. *Rural Property Sales Statistics*. Wellington. Selected issues.
Young, R. and Barry, P.J. (1987). Holding financial assets as a risk response: a portfolio analysis of Illinois grain farms, *North Central Journal of Agricultural Economics* 9, 77–84.