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Why do farmers have so little interest in futures markets?

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Abstract

A farm financial model with leverage and investment in two farm enterprises is specified. The model is extended to incorporate futures hedging and the Separation Theorem is used to show that optimal hedging is zero. The assumption of a risk-free asset is relaxed and, while this leads to a violation of the Separation Theorem, the result that optimal hedging is zero is maintained providing that futures markets are efficient. It is concluded that if capital markets are efficient then farmers will have little interest in futures markets except to speculate. © 2002 Elsevier Science B.V. All rights reserved.

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1. Introduction

The Separation Theorem (ST), attributed to Tobin, states that the farm crop mix will not be effected by attitudes towards risk if capital markets are efficient. The essence of the Theorem is that efficient capital markets, where 'efficient' is interpreted as negligible differences between borrowing and lending rates, mean that farmers can achieve optimal risk exposure entirely by adjusting leverage. It is interesting whether the Separation Theorem can be extended in a simple fashion to specification of optimal hedging rules. That is, if capital markets are efficient, does leverage dominate futures contracts as a strategy for management of farm price risk?

The Separation Theorem is explained in financial texts such as Jones (1998). In Fig. 1, p is the on-farm trade-off between risk and expected return, r the return on a risk free asset, rxmny the risk efficient frontier, and x and y the possible optimal positions for farmers who lend and borrow, respectively. The figure has some capital market 'inefficiency' with different slopes for the borrowing and lending portions of the risk efficient frontier. The figure shows that, except for a small portion of the farm risk frontier, mn, the farmer's optimal position lies above the farm risk frontier and hence optimal response to risk is through leverage rather than changing the crop mix. For a lender, the optimal farm position is m and for a borrower it is at n.

2. Separation Theorem

Assume that utility can be expressed in the form of a mean–variance function

$$u = y - \tfrac{1}{2}k\,\mathrm{vy} \tag{1}$$

where u is subjective expected utility, k the risk coefficient, y the subjective expected income and vy the variance of income. The mean–variance utility assumption has several limitations. First, it is inconsistent unless income is normally distributed (Tsiang,

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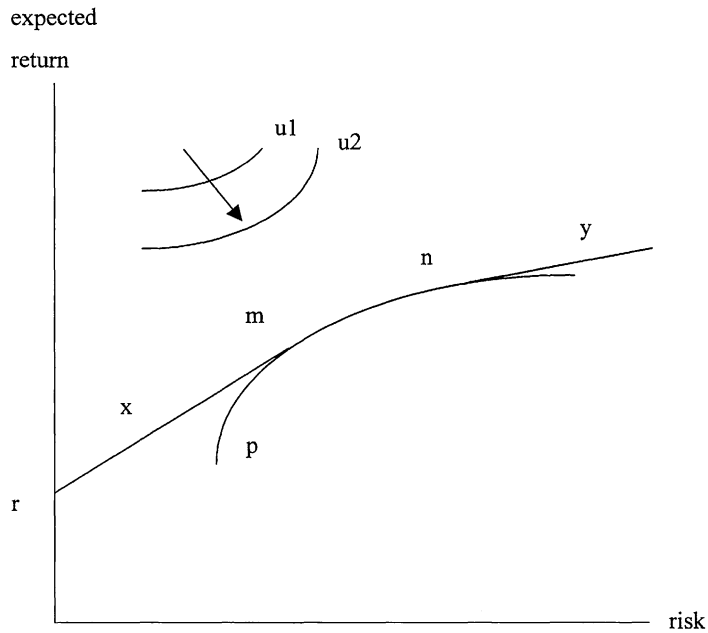

Fig. 1. The Separation Theorem.

1972). Newbery (1988) has shown that errors may occur in calculating hedge ratios from mean–variance utility models if the income distribution is erroneously assumed to be normal. This problem has led to use of constant absolute risk aversion (CARA) utility assumptions which, however, make exact solutions very difficult to obtain. Lapan and Moschini (1994) were able to obtain exact solutions for a CARA specification of the hedge problem, however, only with normally distributed prices, an undesirable assumption. A second limitation of mean–variance utility is increasing absolute risk aversion (IARA) which is inconsistent with econometric evidence for DARA utility in farm populations (Pope and Just, 1991; Chavas and Holt, 1996). While acknowledging these limitations, the mean–variance assumption allows tractable, exact solutions and, hence, it is adopted in this study. In defence of this strong assumption, many important qualitative results from portfolio theory were initially derived in the mean–variance framework and have usually withstood later generalisation.

It is further assumed that the farm has constant returns to scale and produces two crops, s and w. The expected return from farm capital is ra:

$$\mathrm{ra} = \mathrm{ps\,rs} + \mathrm{pw\,rw} \tag{2}$$

where rs and rw are the expected returns from s and w, respectively, and ps and pw the proportions of farm capital allocated to s and w, respectively. Some additional restrictions are applied with ps and pw non-negative, an additivity restriction $\mathrm{pw} = 1 - \mathrm{ps}$, and rs and rw independent, so that $\mathrm{Cov}(\mathrm{rs}, \mathrm{rw}) = 0$.

The farmer borrows or lends at a 'risk-free' rate rb hence the expected return to equity is re:

$$\mathrm{re} = \mathrm{pa\,ra} + \mathrm{pb\,rb} \tag{3}$$

where rb is less than ra or its components rs and rw, pa the ratio of farm value to equity, pb the ratio of borrowing or lending to equity, pa is non-negative to prevent 'shorting' of farm capital and the additivity restriction is $\mathrm{pa} = 1 - \mathrm{pb}$.

Expected utility is obtained in terms of capital returns by assuming there is one unit of equity capital and substituting the two additivity restrictions, (3) and (2) into (1)

$$\begin{aligned} u = {} & \mathrm{pb\,rb} + (1 - \mathrm{pb})(\mathrm{ps\,rs} + (1 - \mathrm{ps})\mathrm{rw}) \\ & - \tfrac{1}{2}k(1 - \mathrm{pb})^2(\mathrm{ps}^2\,\mathrm{vrs} + (1 - \mathrm{ps})^2\,\mathrm{vrw}) \end{aligned} \tag{4}$$

where vrs and vrw are the variances of rs and rw, respectively.

The farmer chooses the crop mix and amount of borrowing or lending hence the decision variables are pb and ps. Using Mathematica 3.01 by Wolfram (1996) here and elsewhere to undertake the math, first-order conditions to maximise u are

$$\frac{\partial u}{\partial \mathrm{pb}} = \mathrm{rb} - \mathrm{ps}\,\mathrm{rs} - (1-\mathrm{ps})\,\mathrm{rw} + k(1-\mathrm{pb})((1-\mathrm{ps})^2\,\mathrm{vrw} + \mathrm{ps}^2\,\mathrm{vrs}) = 0 \tag{5.1}$$

$$\frac{\partial u}{\partial \mathrm{ps}} = (1-\mathrm{pb})(\mathrm{rs} - \mathrm{rw} - k(1-\mathrm{ps}) \times (\mathrm{ps}\,\mathrm{vrs} - (1-\mathrm{ps})\mathrm{vrw})) = 0 \tag{5.2}$$

(Second-order conditions are reported in Section 4 for a more general version of the model.) (5.1) and (5.2) are solved simultaneously for pb and ps:

$$\mathrm{pb} = 1 - \frac{(\mathrm{rs}-\mathrm{rb})\mathrm{vrw} + (\mathrm{rw}-\mathrm{rb})\mathrm{vrs}}{k\,\mathrm{vrs}\,\mathrm{vrw}} \tag{6.1}$$

$$\mathrm{ps} = \frac{(\mathrm{rs}-\mathrm{rb})\mathrm{vrw}}{(\mathrm{rw}-\mathrm{rb})\mathrm{vrs} + (\mathrm{rs}-\mathrm{rb})\mathrm{vrw}} \tag{6.2}$$

An increase in pb corresponds to reduced borrowing or increased lending thus, from (6.1), an increase in rb (or reduction in rs or rw) reduces borrowing or increases lending. An increase in risk aversion, k, reduces borrowing or increases lending. When k is zero, (6.1) has no solution because of the assumption of constant returns and the 'replication argument' (Varian, 1992). From (6.1), if rs increases then investment in s increases and, as expected, if rw increases, ps falls. There is no solution if vrs and vrw are zero since only the crop with the highest return is produced under these circumstances.

From the standpoint of this study, the most important result, from (6.2), is that k does not influence on-farm allocation of capital. This reflects the Separation Theorem that states, in the context of farming, that if capital markets are efficient then the crop mix is not influenced by risk preferences.

3. Separation Theorem with hedging

In this section, the model is extended to incorporate a futures market for w. To limit the number of new variables, the simplifying assumption is made that the futures market is in rw, the return to capital in crop w. This is equivalent to having a futures market for w where the price of w is the only source of variation in rw. This assumption, which amounts to suppressing production risk, is benign so long as farmers, taken as a group, are not price makers with production risk correlated across their industry (Grant, 1985).

The extension, based on Telser (1955), is undertaken by modifying (2), so that

$$\mathrm{ra} = \mathrm{ps}\,\mathrm{rs} + \mathrm{pw}(\mathrm{rw} + h(\mathrm{fp} - \mathrm{rw})) \tag{7}$$

where h is the hedge ratio and fp the current futures price for a contract maturing at harvest expressed as a rate of return on investment in w. Hence, if rw falls after hedging, the farmer receives $\mathrm{pa}\,\mathrm{pw}\,h(\mathrm{fp} - \mathrm{rw})$ dollars and, if rw increases, margin calls of $\mathrm{pa}\,\mathrm{pw}\,h(\mathrm{fp} - \mathrm{rw})$ are paid. Speculative gains are possible if the market is inefficient and fp is biased so that $\mathrm{fp} - \mathrm{rw} \neq 0$ (Newbery and Stiglitz, 1981). The same substitutions as in Section 2 are repeated with (7) replacing (2). Expected utility becomes

$$u = \mathrm{pb}\,\mathrm{rb} + (1-\mathrm{pb})(\mathrm{ps}\,\mathrm{rs} + (1-\mathrm{ps})(\mathrm{rw} + h(\mathrm{fp} - \mathrm{rw}))) - \tfrac{1}{2}k(1-\mathrm{ps})^2(\mathrm{ps}^2\,\mathrm{vrs} + (1+h^2)(1-\mathrm{ps})^2\,\mathrm{vrw}) \tag{8}$$

There are now three decision variables pb, ps and h and hence three first-order conditions

$$\frac{\partial u}{\partial \mathrm{pb}} = \mathrm{rb} - \mathrm{ps}\,\mathrm{rs} - (1-\mathrm{ps})(\mathrm{rw} + h(\mathrm{fp} - \mathrm{rw})) + k(1-\mathrm{pb}) \times (\mathrm{ps}^2\,\mathrm{vrs} - (1-\mathrm{ps})^2(1+h^2)\mathrm{vrw}) = 0 \tag{9.1}$$

$$\frac{\partial u}{\partial \mathrm{ps}} = (1-\mathrm{pb})(\mathrm{rs} - \mathrm{rw} - h(\mathrm{fp} - \mathrm{rw}) - k(1-\mathrm{pb}) \times (\mathrm{ps}\,\mathrm{vrs} - (1-\mathrm{ps})(1+h^2)\mathrm{vrw})) = 0 \tag{9.2}$$

$$\frac{\partial u}{\partial h} = (1-\mathrm{pb})(1-\mathrm{ps})(\mathrm{fp} - \mathrm{rw} - h\,k(1-\mathrm{pb})(1-\mathrm{ps})\mathrm{vrw}) = 0 \tag{9.3}$$

Following Kahl (1983), the first-order conditions are solved simultaneously to provide equilibrium values for pb, ps and h

$$\mathrm{pb} = 1 - \frac{(\mathrm{rs}-\mathrm{rb})\mathrm{vrw} + (\mathrm{rw}-\mathrm{rb})\mathrm{vrs}}{\mathrm{k}\,\mathrm{vrs}\,\mathrm{vrw}}$$

$$\mathrm{ps} = \frac{(\mathrm{rs} - \mathrm{rb})\mathrm{vrw}}{(\mathrm{rw} - \mathrm{rb})\mathrm{vrs} + (\mathrm{rs} - \mathrm{rb})\mathrm{vrw}}$$

$$h = \frac{\mathrm{fp} - \mathrm{rw}}{\mathrm{rw} - \mathrm{rb}} \tag{10.3}$$

Comparing (10.1) and (10.2) with (6.1) and (6.2), the equilibrium values for pb and ps are the same as without a futures market. Most importantly, k does not enter (10.3) indicating that the Separation Theorem can be extended to include hedging. From (10.3), the only interest in futures markets is speculative.

4. Variable borrowing and lending rate

An assumption of the Separation Theorem is that the borrowing and lending rate, rb, has zero variance and the theorem is violated if this assumption is relaxed. However, the implications for hedging of relaxing this assumption are not clear. Hence, expected utility is extended to incorporate the variance of rb, vrb > 0, where $\mathrm{Cov}(\mathrm{rb}, \mathrm{rs}) = \mathrm{Cov}(\mathrm{rb}, \mathrm{rw}) = 0$:

$$\begin{aligned} u = {} & \mathrm{pb}\,\mathrm{rb} + (1 - \mathrm{pb})(\mathrm{ps}\,\mathrm{rs} + (1 - \mathrm{ps}) \\ & \times(\mathrm{rw} + h(\mathrm{fp} - \mathrm{rw}))) - \tfrac{1}{2}k(\mathrm{pb}^2\,\mathrm{vrb} + (1 - \mathrm{pb})^2 \\ & \times(\mathrm{ps}^2\,\mathrm{vrs} + (1 + h^2)(1 - \mathrm{ps})^2\mathrm{vrw})) \end{aligned} \tag{11}$$

The first-order conditions are

$$\begin{aligned} \frac{\partial u}{\partial \mathrm{pb}} = {} & \mathrm{rb} - \mathrm{ps}\,\mathrm{rs} - (1 - \mathrm{ps})(\mathrm{rw} + h(\mathrm{fp} - \mathrm{rw})) \\ & -k(\mathrm{pb}\,\mathrm{vrb} - (1 - \mathrm{pb})(\mathrm{ps}^2\,\mathrm{vrs} - (1 - \mathrm{ps})^2 \\ & \times(1 + h^2)\mathrm{vrw})) = 0 \end{aligned} \tag{12.1}$$

$$\begin{aligned} \frac{\partial u}{\partial \mathrm{ps}} = {} & (1 - \mathrm{pb})(\mathrm{rs} - \mathrm{rw} - h(\mathrm{fp} - \mathrm{rw}) - k(1 - \mathrm{pb}) \\ & \times(\mathrm{ps}\,\mathrm{vrs} - (1 - \mathrm{ps})(1 + h^2)\mathrm{vrw})) = 0 \end{aligned} \tag{12.2}$$

$$\begin{aligned} \frac{\partial u}{\partial h} = {} & (1 - \mathrm{pb})(1 - \mathrm{ps})(\mathrm{fp} - \mathrm{rw} - h\,k(1 - \mathrm{pb}) \\ & \times(1 - \mathrm{ps})\mathrm{vrw}) = 0 \end{aligned} \tag{12.3}$$

and second-order conditions (ignoring cross terms) to ensure a maximum are

$$\begin{aligned} \frac{\partial^2 u}{\partial \mathrm{pb}^2} = {} & -k(\mathrm{vrb} + \mathrm{ps}^2\,\mathrm{vrs} + (1 + h^2) \\ & \times(1 - \mathrm{ps})^2\,\mathrm{vrw}) < 0 \end{aligned} \tag{13.1}$$

$$\frac{\partial^2 u}{\partial \mathrm{ps}^2} = -k(1 - \mathrm{pb})^2(\mathrm{vrs} + (1 + h^2)\mathrm{vrw}) < 0 \tag{13.2}$$

$$\frac{\partial^2 u}{\partial \mathrm{ph}^2} - k(1 - \mathrm{pb})^2(1 - \mathrm{ps})^2\mathrm{vrw} < 0 \tag{13.3}$$

Equilibrium values for pb, ps and h are

$$\mathrm{pb} = \frac{k\,\mathrm{vrs}\,\mathrm{vrw} - (\mathrm{rs} - \mathrm{rb})\mathrm{vrw} - (\mathrm{rw} - \mathrm{rb})\mathrm{vrs}}{k(\mathrm{vrs}\,\mathrm{vrw} + \mathrm{vrb}(\mathrm{vrs} + \mathrm{vrw}))} \tag{14.1}$$

$$\mathrm{ps} = \frac{(\mathrm{rs} - \mathrm{rb})\mathrm{vrw} - \mathrm{k}\,\mathrm{vrb}\,\mathrm{vrw}}{(\mathrm{rw} - \mathrm{rb})\mathrm{vrs} + (\mathrm{rs} - \mathrm{rb})\mathrm{vrw} - k\,\mathrm{vrb}(\mathrm{vrs} + \mathrm{vrw})} \tag{14.2}$$

$$h = \frac{(\mathrm{fp} - \mathrm{rw})(\mathrm{vrs}\,\mathrm{vrw} + \mathrm{vrb}(\mathrm{vrs} + \mathrm{vrw}))}{\mathrm{vrw}(\mathrm{vrs}(\mathrm{rw} - \mathrm{rb}) + \mathrm{vrb}(\mathrm{rw} - \mathrm{rs}) + k\,\mathrm{vrb}\,\mathrm{vrs})} \tag{14.3}$$

From (14.2), relaxing the 'risk-free asset' assumption violates the Separation Theorem since k now influences the crop mix. While the same appears to be true of the hedging decision, (14.3) warrants further examination. If rw, the subjective expected return to investment in w, differs from fp (in the first bracketed term in the numerator) then speculation occurs with k influencing the level of speculative activity. However, if the farmer believes that the futures market is efficient, so that $\mathrm{fp} - \mathrm{rw} = 0$, then h is zero. There will be no hedging by farmers if they believe that futures markets are efficient.

5. Hedging in Australia

Australian farmers have access to domestic futures and options markets for wheat, beef and wool and can also access foreign hedging markets for cotton. Hedging by wheat and wool growers is low with Lubulwa et al. (1997a) finding less than 4% of wheat farmers using futures markets and Lubulwa et al. (1997b) finding futures usage by wool producers was around 2–3%.

In contrast, use of hedging by Australian cotton producers is believed to be more widespread. While published estimates of use of futures and options markets are not available, personal communication

Table 1
Farm financial measures for selected industries in Australia in 1996–1997 (source: ABARE, 1998)

	Wheat and other crops	Sheep and beef	Cotton
Total cash receipts	$398,720	$122,170	$1,129,522
Total cash costs	$274,660	$96,880	$721,998
Farm capital	$1,778,370	$1,026,210	$2,524,525
Business equity ratio	83.1%	90.4%	73.2%

by the authors in supervising undergraduate theses on cotton hedging indicates wide use of American markets by Australian cotton producers for hedging. Australian cotton producers use the New York markets for hedging in conjunction with exchange rate hedges. In addition, sales (of the majority of the harvest) through pooling arrangements are usually hedged.

Summaries of financial statistics from ABARE (1998) reported in Table 1 indicate both similarities and differences between the broad-acre group, wheat and other crops and wool, and the cotton producers. Generally, both groups have high capital value, good receipts and profitability and make use of debt to finance farm investment and, presumably, in bad years, farm household income. However, cotton producers have lower equity ratios and make more use of debt, particularly intra-seasonal debt.

The higher levels of debt held by cotton producers are consistent with the Brorsen (1995) result that high levels of borrowing can provide incentives for even risk neutral farmers to use futures markets. Brorson's result stems from the non-linear nature of borrowing costs when debt is high. That is, high borrowings result in higher lending margins and hence bad years result in high margins that make futures hedging, on average, a sensible activity. Brorson's theory is consistent with the thesis presented in this paper regarding the Separation Theorem. That is, non-linear borrowing costs cause the risk frontier, rxmny to 'bend around' the farm frontier p increasing the size of mn, the segment of the possibility frontier where the Separation Theorem is violated and on-farm risk avoiding behaviour may be optimal. This may explain the relative popularity of hedging amongst Australian cotton producers.

6. Discussion and conclusions

The analysis shows that under our assumptions the Separation Theorem is relevant to understanding of demand for futures contracts by farmers. This provides a possible explanation for the evidence that many farmers do not hedge on futures markets (Berck, 1981; Lubulwa et al., 1997a,b; Simmons and Rambaldi, 1997) and, through the speculative component of the model, a possible explanation of why some do. A perspective is also provided on commodity futures markets since, under our assumptions, these are simply clearing houses for market information and are unlikely to be used for hedging.

A key assumption in the analysis concerns the treatment of transaction costs. Transaction costs in futures markets were assumed to be zero and in capital markets they entered (3) implicitly through the choice of borrowing and lending rate.

Direct costs for farmers dealing in Australian futures markets are around 2% of the value of contracts. At this level, costs should not strongly influence the decision to hedge unless risk premiums are very small, in which case farm hedging may not be an issue anyway. In addition, inclusion of positive futures transaction costs would presumably discourage hedging and strengthen our conclusion that futures as a way of hedging may not be attractive to farmers, given options in capital markets for management of risk.

Transaction costs in capital markets were implicitly included in the interest rate and an important simplifying assumption here was that borrowing rates are independent of the level of borrowing. Brorsen (1995) has shown that risk neutral agents will hedge if borrowing costs are 'non-linear' and that such hedging increases with debt levels. In the context of the Separation Theorem, Brorsen's result might be explained by adapting the traditional textbook figure (Fig. 1), so that non-linear borrowing costs cause the risk-efficient frontier to 'bend' around, and hence incorporate, part of the farm E–V frontier. It seems likely that high lending margins associated with relatively high debt explain some of the observed futures activity by farmers. An example was given of Australian cotton farmers. Since the results of our analysis are likely to change if these variable margins were explicitly incorporated into the model, this could be an area for further investigation.

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