Emerging Issues in Risk Management in Farm Firms

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Farming is a high risk business because of the inherent variablility of the natural environment in which it is placed and the markets in which its products are sold. Farmers have learned to cope with variability and have adopted management strategies which decrease risk to the farm firm. This paper examines the literature on emerging issues in risk management in agriculture and how farmers might react in the future. Attention is focused on managing changes in risk exposure due to climatic variability and market variability, and on management measures that protect the structure of the farm business.

1. Introduction

This paper reviews the literature on risk management strategies in agriculture. Standard economic models of the farm firm demonstrate how risk influences farm decision making and is an important factor in underinvestment and firm survival (Gabriel and Baker; Patrick *et al.*; Johnson; Sonka and Patrick; Barry and Fraser; Boggess *et al.*). If net operating income of a farm firm consistently fails to exceed prior commitments, the survival of the business is threatened. The objective of risk management is to reduce the chances of a vulnerable situation like this occuring, while at the same time maximising returns to equity owners consistent with their attitudes to risk (Martin). In assessing the strategies available, the owner/manager must explicitly or implicitly rank the probabilities of adverse events occuring. Considerable research has taken place into such rankings with results which emphasise how risk perception varies from individual to individual, farm type to farm type, and region to region (Martin; Patrick *et al.*; Scott; Ralston and Beal). Strategies to control risk can focus on risk exposure or on minimising risk to the farm business.

Risk exposure in agriculture is linked to the two quite distinct causes of climate uncertainty and market uncertainty in the future. These uncertainties can be partially mitigated by manipulating the probability distributions of the variables facing the farm business to reduce variability in future income flow. In dryland farming, yield uncertainty can be reduced by appropriate management practices (time of sowing, weather forecasting, mix of crops, crop insurance, etc), but cannot be eliminated. The farm plan must be flexible enough to accommodate the expected range of results. In irrigation farming, yield uncertainty is much reduced and variation in expected income consequently reduced. But, as discussed further below, irrigated agriculture introduces other uncertainties particularly those related to water depletion and externalities.

Market uncertainty has to be managed by strategies which reduce effects of price fluctuations on the farm firm. For the individual farmer, the strategies are limited. Apart from with-holding product from sale, farmers have to seek forward contracting arrangements, or where available, sell in futures markets. The scope of the latter is limited in Australia. On the other hand, farmers acting collectively can pool their marketing risk. The ultimate collective is a statutory marketing board with powers to hold year-to-year reserves and run up debt with banks. In principle, marketing boards should *spread* risk in a meaningful way from year to year, region to region, and crop to crop. In point of fact, single commodity boards have been unable to offer this insurance facility, and have run into difficulties in the long run.

Structural risk is concerned with maintaining the farm business' survival. Strategies include conservative financing and purchasing of land (Madden and Malcolm), maintaining adequate financial reserves against misfortune, and sharing risk with other entities as in equity financing, share-farming, and leasing. Managers need to have a *risk management plan* (explicit or implicit) which assesses the uncertain outcomes in the year's operations and allows for reasonable variation in the expected outcome. A risk management plan is implicit in the financial management goal of earning a

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positive risk-adjusted return on owner's equity. Some managers may be more conservative than others in setting such a goal. This is not a question of varying risk aversity for all farmers, but more a question of setting appropriate goals in an uncertain production environment.

In the following sections, the paper first reviews recent literature concerning climate and market uncertainty, then secondly reviews strategies for protecting the structure of the farm firm under uncertain outcomes. The first two sources of risk are usually assessed together as business risk, and the third source as financial risk.

2. Management Strategies

2.1 Climatic Uncertainty

2.1.1 Dryland farming

The development of compact, relatively cheap and high-powered personal computers has opened up an opportunity for farmers to introduce sophisticated information, planning and control systems relating to production, marketing and finance to reduce risks. Researchers in many nations are taking the opportunity to build new models and techniques.

In Australia researchers at the CSIRO have developed a comprehensive computer-based management system for the production of wheat. The system deals with irrigation scheduling, fertiliser and herbicide application, and disease prediction. The model was initially accessible by telephone link. The model will be used additionally to assess the cost effectiveness of alternative management decisions (Muirhead *et al.*). The *Rainman* computer program, developed by the Queensland Department of Primary Industries, links indicators of the climate system such as the Southern Oscillation Index to probabilities of local rainfall to provide a decision-support system (Kininmonth).

2.1.2 Irrigation farming

Recently reported research shows that net returns from crops under irrigation are usually increased and the variability of returns reduced, as might be anticipated, but also that irrigation creates secondary problems with risk components (Burt and Stauber; Apland, McCarl and Miller). These issues mostly relate to the depletion of surface- and groundwater resources, competition between competing uses for water, socially-optimal pricing of water, the effects of unexpected loss of supplementary water, and the risk of increasing salinity.

The application of irrigation water, no matter whether by spray, drip or flood methods, involves capital investment, usually with a long payback period. Conflict over water supplies, competition for water rights or depletion of useable supplies add uncertainty to investment decisions and may ultimately impact on both business and financial risk.

Another long-running issue in irrigation is the conflict between subsidised prices for water and economic efficiency. In the USA, farmers in the western states have been able to purchase subsidised water since 1902 from the Bureau of Reclamation. Critics have argued the subsidies have encouraged waste of water. Kanazawa suggested entitlement ceilings may force users to manage water use appropriately, and use may be neither excessive nor as responsive to pricing reform as critics believe. Irrigation in the Murray-Darling Basin in Australia is subsidised in the order of $300m a year, but emphasis is changing from support for regional development to partial recovery of operational expenses (Simmons, Poulter and Hall).

At times when water pricing is on the political agenda in nations, states or local areas, uncertainty is introduced to investment. (The uncertainty may be that pricing will be introduced for the first time or that current prices will be changed.) Either case makes capital budgeting more difficult and financing more expensive. Financial risk is likely to be increased and policy or government failure may follow. The better these processes are understood, the better decision makers can take them into account in their long-run investment planning.

2.1.3 Climate change

The potential effects of both global climate changes and local ecological changes do not have the immediacy for farmers of BSE (bovine spongiform encephalitis) in the herd or a cloud of locusts descending on the best grain crop in 10 years. The effects, however, may be just as disastrous in local areas in the long-run.

Scientists have warned in recent years that the earth's climate is changing (Cline). Long-run warming of the planet will affect critical climate variables for agriculture: rainfall, wind patterns, cloud cover and the level of the sea. There will be consequent changes in such physical factors as soil conditions, availability of water, and salinity levels. Farming systems and production will also change (Ramirez).

Few governments or managers appear to be planning for greenhouse effects on production patterns, although in the USA one firm is investing in plant breeding to incorporate drought resistance into tree varieties to plant in expected newly arid areas (Ramirez). Mendelsohn, Nordhaus and Shaw examined the impact of global warming on agriculture in almost 3 000 counties in the USA in a 'Ricardian' analysis of the impact on land values and farm revenue. They found a significantly lower estimated impact on US agriculture than the traditional production function approach suggests due to simultaneous adjustment processes.

The CSIRO has developed for Australia several scenarios of possible changes in regional climates. Generally, summer rainfall may be 0-20 per cent greater by the year 2030 and 0-40 per cent greater by 2070. The outlook for winter rainfall is more complicated. Some extremely southern areas may become wetter, some northern regions drier, and the wheat-belt and intensive agricultural areas may be wetter or drier with local determinants having a significant effect. Temperatures and evaporation may change. Increased evaporation could increase the frequency of local droughts, even where rainfall is enhanced. The most significant impacts are likely to be the increased frequency of extreme events, including both droughts and floods (Fowler and Hennessy).

Rising carbon dioxide levels will increase crop yields, but also the vigour of weed species. In the pastoral zone, already affected by rampant woody weeds such as *Parkinsonia, Myoporum* and *Eremophila* spp. and *Acacia farnesiana,* predicted changes will favour woody plants over grasses. Increased carbon dioxide will reduce the time interval when fodder grasses are most nutritious for grazing stock. Hence, the combined effects of these impacts will require a higher level of management expertise and perhaps changed systems of agricultural production (Pearman, Manton and Walker). These are essentially long term changes in production risk.

Significant changes in the potential distributions and effects of a range of animal, including human, and plant pests and diseases are likely (Pearman, Manton and Walker). Tropical pest plants and insects may extend their range south. The Queensland fruit fly, for example, (and the papaya fruit fly, discovered in north Queensland for the first time late in 1995, if it is not successfully eradicated) could move south to inflict significant loss on horticultural producers in lost markets, lost production and increased costs (Pittock).

In addition to the effects and costs of likely climatic changes, the measures being taken to mitigate global warming have agricultural impacts. Strategies to reduce fossil fuel emissions are likely to increase the cost of energy, thus raising the cost of operation of machinery, the cost of pumping water and the cost of fertiliser and other inputs. Some land may be diverted to forestry production to store carbon and to produce renewable fuel (Rosenberg and Scott).

Although Australian producers face risk in probable changes in environmental components necessary for profitable production, Godden pointed out that the effects of changes will be conditional upon management responses, including changes in practices and enterprise mixes. Moreover, structural changes, or lack of them because of governments' non-response, will impact on the cost structure of farms. These areas of uncertainty should be included in manager's investment decision processes, where investment is expected to generate returns into the reasonably long term.

2.1.4 Externalities

Not least among the adverse consequences which have become apparent in the longer term after investment in irrigation schemes is the increase in salinity of soils. Irrigation-induced salinity (and dryland, as well) are examples of Munck's Darwinian boomerang (see below p.339). Other examples are increased pest resistance and off-site effects of increased water use in agriculture.

Parts of the Murray-Darling Basin in Australia and many places in California are cases of prime agricultural areas which have suffered adverse effects of salinity induced by irrigation. Simmons, Poulter and Hall found salinity of the Murray-Darling system cost the community about $100m a year in the early 1990s. They suggested further research was necessary to determine policy regarding amelioration measures involving transferable salt emission quotas, salt emission taxes, tailwater standards and subsidy of alternative practices. Knapp and Dinar analysed irrigation strategies with irrigation water of given salinity and constructed a model involving the evapotranspiration of plants, soil moisture, soil salinity and crop yield. They applied the model to the production of cotton in an area in California and found the amount of water applied was influenced by initial salinity levels and drainage disposal costs.

The effect of irrigation-induced salinity on land values has come to the attention of real estate appraisers and valuers. Farmers in the San Joaquin Valley in California have long been warned that rising saline water tables will increase costs and reduce yields. These effects will thus enter into risk perceptions (Claus, Large, and Claus).

Dryland salinity has been observed in cropping and grazing areas in the USA (Miller *et al.*) and in all States of Australia (SCSC). The situation is acknowledged to have become worse during the last two decades (Shaw). Re-establishment of tree cover and groundwater pumping, which may increase financial risk through increased borrowing and investment, have been investigated as remedies for the problem (Doherty and Stallman). Farmers have developed the conditions necessary for outbreaks of dryland salinity and incur this ecosystem risk by trying to increase production to levels greater than those that ecosystems can sustain, probably as a result of the pressure of financial leverage.

As far as climate change and externalities are concerned, policy debate and public response to the greenhouse issue has largely been limited to mitigation of the buildup of greenhouse gases. The majority of farmers are, however, unlikely to change their practices regarding burning, minimum tillage, use of fossil fuels, livestock numbers and ruminant feed digestibility, all of which are implicated in the greenhouse gas issue (Hall *et al.*), just to decrease the externalities they inflict on the biosphere. Nevertheless, it would be prudent for farm managers to make investment as flexible as possible to allow for possible shift in enterprise selection, and to put emphasis in planning on dealing with varying availability of water (Sonka). Climate change has the long run potential to impact on business risk through unexpected changes in yields and input requirements, financial risk through changes in land prices and equity levels, and policy risk through the uncertain reactions of governments to perceived change.

A second area where risk has increased rather than reduced is the increasing resistance shown by insects, fungi and bacteria to farm chemicals which have been applied to crops, pastures and livestock to minimise production risk. A large literature has developed in scientific journals concerning chemical resistance (Mani; Dover and Croft; Brookfield). Humankind has selected and used various resources from the natural environment, and has developed a multitude of machines and systems which impact or exert selection pressure on the environment. Some species or components have been depleted, and others have been favoured, allowing their populations to prosper. Munck suggested that human beings are essentially unaware of the dynamic, unseen effects of their selections, due to the complexity of ecosystems. Humanity is then 'surprised, even insulted, when the environment from which we selected, changes or even strikes back ... the side effects of human selection is a Darwinian boomerang, in the end striking man and other species through natural selection' (Munck, p.217).

Ecological risk is used as a generic phrase to capture all these phenomena which arise due to farmers' manipulation of their local ecosystems. Pests and diseases are often given an unwanted advantage by the monocropping systems which modern agriculture must adopt to gain the economies of scale implicit with mechanisation. Dryland salinity is usually caused by over-clearing groundwater recharge areas, such that water tables under valley floors rise, bringing salt into plant rootzones and destroying productive capability. Soil erosion results from inadequate management of the soil surface in places where rainfall or winds pose threats.

Oglethorpe examined the intensity (over-use of artificial inputs) of farmland use and the consequent danger of degradation of the resource to the risk preference of farm managers in a study conducted in the northern areas of England. The study used directly elicited utility functions and found that enhanced perceptions of risk encourages the use of less intensive methods, which could assist the achievement of environmental policy goals.

Ecological risk has developed because of managers' lack of understanding of the complexity of ecosystems. Excessive pressure asserted against natural entities and systems will often yield unexpected results of environmental degradation and loss of productive capability. Ecological risk is likely to increase in many parts of the world in the near future, and is only likely to decrease when proven biologically-sustainable production systems are in place.

The depletion of water resources increases the risks associated with water investment. Many areas of the world face dwindling water supplies, not least parts of the USA and areas of Australia. Postel reported in relation to the USA that water management policies have generally focused on water development to stimulate economic growth and ignored planning for a limited supply. Many water rights and laws have been biased against conservation. She recommended more efficient irrigation techniques, taxes on pumping from depleted aquifers and pricing of water at its true social cost making resource risk more transparent.

Competition between users raises costs of water, creates conflicts in property rights, and adds uncertainty to investment decisions. One aspect of a depleting resource is that users are forced to compete for the right to use the resource. Competition may apply between countries sharing a watershed, states or counties within nations, users such as farmers and urban residents and uses such as farming and hydroelectric power generation authorities. Kaye reported the international difficulties that were being experienced between India, Nepal and Bangladesh in sharing the waters shed from the Himalayas between the nations and between farming and hydroelectric uses. Faruqui, concerned with the conflict between the use of water resources for irrigation and for hydroelectric generation in Pakistan, concluded demand management of power was necessary, even though developing nations have comparatively low levels of per capita energy consumption.

Competition for water also takes place between rural and urban users. Rivalry is likely to become more severe in many nations. Caswell and Zilberman examined the management of California's water resources. They found farmers currently use more than 80 per cent of developed water supplies, but face increasing nonagricultural demand for water. Limited water resources will likely induce institutional change and adoption of new low-volume water-conserving technology. Rosen and Sexton applied cooperative and club theory models to analyse the response of water supply organisations, which control a large portion of the agricultural water supply rights in the western USA, to potential transfers of water to urban users. They found substantial conflict within organisations, resulting from poorly defined property rights and inappropriate alignment of property rights with operational control. Conflict was sufficient to defeat or delay otherwise beneficial transfers and increase risk for investors.

Water pricing is likely to be an important production risk issue into the next century as countries raise charges to meet costs and recover previous subsidies. Apart from appropriate water pricing increasing allocative efficiency and likely to reduce problems of drainage and pollution (Briggs Clark *et al.*; Fenwick; Dinar and Letey), other water pricing issues have been canvassed in the literature. Torell, Libbin and Miller computed the value of groundwater from the Ogallala Aquifer, which underlies eight states in western USA. They used market data for the difference in the value of production from irrigated land as opposed to dryland to compute the enhanced value of groundwater. The investigation was prompted by a court ruling allowing an income tax deduction to compensate for falling land values as groundwater is exhausted and irrigation farms return to dryland production.

Legislators in the USA and Australia have recently become conscious of the need for the community to gain more value from rural assistance funding. To this end, production of evidence of a commitment to risk reduction through the conservation and sustainable use of resources and improvement of productivity have been linked to the granting of assistance. In the USA, these conditions were introduced in the 1985 and 1990 farm laws (Breimyer). The Rural Adjustment Scheme in Australia similarly now incorporates an objective of sustainable production (Holden). Such systems support more conservative use of resources and hence are risk-reducing.

2.2 Market Uncertainty

Market risks may be ameliorated by storage strategies, futures trading, or by certain government interventions of a collective nature. In a survey of 770 farmers in Southern Queensland, it was found that the majority of respondents favour storage of produce which was used to at least some extent by 90 per cent of crop growers, 84 per cent of mixed farmers, 67 per cent of fruit and vegetable growers, and 44 per cent of livestock producers. Marketing through pools was highly favoured by crop growers (75 per cent) and mixed farmers (76 per cent), while forward selling was practised by crop producers (83 per cent), mixed farmers (50 per cent), and fruit and vegetable growers (45 per cent). The least favoured marketing techniques were computer-aided livestock marketing (CALM) and direct export. CALM is used by 25 per cent of livestock producers and 30 per cent of mixed farmers, while direct export was only used to any extent by fruit and vegetable growers (Ralston and Beal).

2.2.1 Storage

Farmers in many countries have traditionally responded to price variability by storage of both their produce and, to a lesser extent, their input needs. Storage is managed by adjusting the timing and size of market transactions, thereby aiming to increase net returns and lessen the variability of returns (Barry, Hopkin and Baker). To some extent, storage may substitute the risk of destruction by fire, disease, rodents, insects or other natural elements and foregone interest revenue or increased interest cost for the market risk of price variability. Strorage is regarded as a dominant strategy in Southern Queensland.

However, stockpiles may affect future market operations. At the end of 1995, the wool industry in Australia was hampered by a large official stockpile which was being liquidated at a planned rate regardless of market conditions. In addition, there was reportedly a secondary stockpile in brokers' stores as growers passed in wool on a dramatically falling market, and an alleged growing stockpile in woolsheds across the producing areas. The buildup of wool in storage significantly affected the outlook for wool prices and thus probably increased market risk (*QCL*).

2.2.2 Futures trading

Hedging through use of futures contracts, forward price agreements or options is another avenue open to producers to minimise price variability. The Sydney Futures Exchange (SFE) was founded in 1960 as the Sydney Greasy Wool Futures Exchange. By 1973, SFE was the leading wool futures market in the world, displacing exchanges in the USA, UK, and the EC, and traded contracts equivalent to about 3 million bales that year. Activity in wool futures declined after that date, due to the Reserve Price Scheme and other factors.

The SFE has introduced other agricultural commodity contracts in order to increase trading, but only the 'fittest' contracts survive. Successful futures contracts have acceptable specifications, enjoy a high volume of trading, have greatest liquidity and have the lowest buy/sell margins. The SFE boxed beef and live young cattle contracts encountered difficulties with acceptance and liquidity, on one hand, and places of delivery and assessment of the cattle, on the other. Cash settlement only is an option which has often been adopted to solve delivery problems. Late in 1995, the SFE announced the introduction of a wheat contract.

Major shortcomings with futures for risk management in agriculture are the unavailability of contracts for many commodities, specifications of contracts being unsuitable for many farmers' situations and lack of understanding by farmers of the tool (Trewin *et al.*). In an effort to develop risk management tools and growers' understanding and use of them, Wool International in Australia is planning to undertake a two-year trial of innovative marketing methods for wool. Forward buying of growers' wool, forward and futures trading, and derivatives trading will be used. This significant trial will be funded to the extent of about $20 million, and is seen as a logical development of risk management tools in the aftermath of the failed Reserve Price Scheme (Patterson and Shelton). However, a successful outcome to the trial may not induce many growers to accept futures trading as a marketing tool. Wahlquist argued most woolgrowers practise risk management by changing enterprises, and cited a 17 per cent decline in the number of Australian farms producing wool and a decrease in production per farm during the 1989-1995 turbulent market period[1].

The need to nurture the development of marketing options in the wool industry is in stark contrast to the case of the cotton industry. This fibre industry developed in Australia in a deregulated marketing environment and embraced a full range of marketing risk management options, including Chicago futures trading (Mues).

The Australian experience is not unique. Even though the Chicago Mercantile Exchange (CME) and the Chicago Board of Trade (CBOT) deal in an extensive range of agricultural commodities including wool, frozen orange juice, cocoa, coffee, barley, butter, soybeans, pork bellies, corn, cotton and cattle, the volume of agricultural commodity trading in 1993 was 20 per cent of that achieved in the late 1970s (Einhorn). In the USA, the market has been affected by claims of market manipulation. Oellermann and Farris investigated concentration among traders of two cattle contracts, but found no evidence of price manipulation. However, CBOT was forced to take emergency action for the liquidation of the July 1989 soybean contract when an Italian conglomerate tried to corner the market. As a result, new price protection measures were explored (Mahlmann).

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[1] Some of decrease in production would be due to protracted drought.

In Australia, the CALM system offers weekly sales of cattle, lambs, sheep and pigs by response to a computer display. CALM acts as a price-discovering service to industry and allows producers to manage their marketing risk, as stock are offered *at farm gate*. Producers selling stock at saleyards, on the other hand, have already incurred expense in transporting their stock, and are likely to accept lower than expected prices than incur additional expense. Despite what would appear to be evident risk management advantages of CALM, only 25 per cent of livestock producers and 30 per cent of crop producers reported using CALM in the Ralston and Beal survey, and only 1-3 per cent of national stock sales are made through CALM (Johnston).

2.2.3 Collectivised risk management strategies

Many national governments are involved in agricultural commodity markets, as a result of rent-seeking, economic arguments and equity considerations. Marketing boards are a statutory response to market risk. The economic argument is that government action may reduce the risk faced by individual producers and thus encourage investment in riskier projects which will have a higher national benefit. If the cost of the intervention is lower than the resultant benefits, there will be a net gain to society (IAC). Many marketing boards have not been able to meet this criterion.

Part of farmers' concern for assistance with the marketing of produce is driven by the deregulation of commodity marketing boards in Queensland. In the decade from 1983 to 1993 the number of boards operating under the *Primary Producers' Organisation and Marketing Act 1926*, fell from 13 to 1, with another in receivership (Jarrett and Brown). Of the 11 boards which were wound up, six were replaced with producer cooperatives, three with producer controlled unlisted companies, and two by public listed companies. While these reforms were producer-initiated, they increased the uncertainty surrounding the price of commodities, particularly in the grain and cotton industries.

Whilst government intervention is supposed to reduce risk, sometimes the opposite effect is achieved. Increased risk can occur through uncertainty in the future continuation or direction of the policy, such as occurred during the last months of the Australian Wool Reserve Price Scheme (ABARE). Alternatively, the policy may fail to meet the desired objectives. Moore, for example, found in relation to US farm policy that programs do not reduce risk to producers or consumers' food prices, and most aid does not go to farms with large debt or with cash flow difficulties. He further found that the benefits of farm programs are capitalised into higher land values, and the winners are landowners who held land before the announcement of the programs. Innes investigated the efficacy of price support as an intervention tool and found, under conditions of incomplete markets, farmers' being risk-averse, and low price- and income-elasticity of agricultural commodities, that farmers can be made worse off and consumers better off.

Concern over the uncertain outcomes of farm policies prompted Just and Zilberman to develop a microeconomic model to examine the effects of five types of farm assistance on income distribution and the uptake of technological advances. They found distributional effects to be dependent on, and the uptake of new technology to be affected by, farmers' risk preference, farm size and availability of credit.

2.3 Modelling Risk Management Strategies

Modelling can simulate the trade-offs between profits and production risk strategies. There has been an interest in developing computationally simple methods for farm risk planning that are suitable for microcomputers and hand-held calculators (Collins and Barry). Risk programming models such as linear programming, quadratic risk programming, MOTAD programming, target MOTAD and stochastic programming approaches have all been used to aid decision-making under uncertainty (Hardaker *et al.*). Concern has been expressed that the research effort expended on risk modelling has not been matched by a corresponding understanding of the importance which producers attach to the strategies being modelled (Martin).

In recent studies, diversification and strategic planning were examined in a mathematical programming model to evaluate long-term alternatives for a US broiler farmer considering diversification into aquaculture. The findings were that diversification with hybrid striped bass would significantly increase profitability whilst maintaining financial risk below a maximum tolerance level (Aull-Hyde, Gempesaw and Tadesse).

Modelling enterprise choices with different risk levels with the capital asset pricing model (CAPM) demonstrates clear trade-offs between profit and production risks (Johnson). Systematic risk, common to all firms in an industry, is differentiated from non-systematic risk which results from individual decisions and activities of each firm. Portfolio theory and CAPM have been applied to farm enterprise selection with various programming models. Arbitrage pricing theory (APT) has also been examined in relation to agriculture (Johnson). It has not been fully explored yet in its application to farm firms. More recently, the CAPM has been extended to an analysis of the barriers to the flow of equity funding of farm land and finding a reasonable explanation of the inadequacy of APT models in explaining equity pricing in farm land markets. Wagner, Cubbage and Redmond have computed CAPM and traditional capital budgeting techniques for several forestry investments and found combined methods offered more explanatory power than the traditional capital budgeting methodology.

Kim *et al.,* adopted an optimal control model to resource depletion and, using data from the Texas High Plains, found positive financial benefit of groundwater management and transition away from irrigation of sorghum. Tsur and Graham-Tomasi have modelled the buffer value of groundwater when surface supplies are subject to fluctuation and users subjected to risk.

In related research, Teague, Bernardo and Mapp developed a risk programming framework which evaluates income-environmental risk tradeoffs for a farm in the Oklahoma Panhandle region of the USA. They found expected income to vary proportionately to selected environmental degradation indicators.

In summary, Eidman has drawn attention to the need to develop appropriate risk estimates for decision analysis in farm planning. He argued that a great deal of further research is needed to estimate an appropriate and consistent set of distributions for the problems being analysed. One problem is finding appropriate distributions for individual situations (Martin; Johnson). Another problem is that different measures of risk give different results for crop selection (Johnson). Research should be focussed on the empirical basis for risk analysis by identifying the importance which producers attach to different risk management strategies (Martin).

2.4 Structural Risk

Financial risk management involves leverage, liquidity and insurance protection against disaster to protect the structure of the farm (Barry, Hopkin and Baker). In more recent years in the USA and especially in Australia with drought and ever declining terms of trade, off-farm work and income for both male and, more significantly, female farm partners has become an important additional aspect of risk management (Kyle; Peterson and Moon). Also relevant are equity funding, and risk partition and sharing, i.e. through share farming.

Leverage or gearing is the use of borrowed funds to earn a greater return on the funds than their cost. The net effect is to enhance the return on shareholders' funds or equity. In agriculture, the envisaged net positive return on the borrowed funds is not always forthcoming, and the net effect of borrowing is that the return on equity is decreased. Declining equity traditionally is managed by delaying investment in new infrastructure or technology, or by selling non-core assets. Nicholas and Horton found annual expenditure on plant had decreased by about 60% between 1979-80 and 1992-93 on cropping farms in Australia due to lack of profitability.

In a Queensland survey, it was found that there were a significant number of farmers who reduced debt as a response to increased financial risk (Ralston and Beal). Respondents who reduced debt were less likely to seek advice from their bank manager and more likely to use commercial interests as a source of advice on financial planning. Those who reduced debt were more likely to adopt higher levels of risk in their decision making.

Another option to reduce financial risk is the introduction of external equity capital. This shares risks between owner and lender. Crane and Leatham (1993) examined the potential for the introduction of Islamic banking-style profit and loss sharing instruments to US agriculture. Acceptance of this innovation would rest solely on its economic merits rather than being clouded by religious issues as in the Islamic world. Still working on this problem, Crane and Leatham (1995) proposed an institutional arrangement and contracting procedure for US farmers by which external suppliers would receive equity in farms instead of debt. They presented an accounting schedule for calculating the equity division between owners and input suppliers to reflect relative risk carried.

Financial deregulation has increased financial risk for all businesses, including farmers. In non-agricultural businesses, such financial risks as interest rate and currency risk is managed with the use of derivatives and swaps. The large retailer, Woolworths, for example, manages its exposure to interest rate fluctuations through interest rate swaps to optimise the mix of fixed and floating rate funding. The company manages its foreign exchange risk exposure by buying or selling foreign exchange forward to fix prices (Woolworths). It is difficult to envisage the agricultural sector wholeheartedly taking up the challenge of derivatives in the immediate future. However, the cotton industry has enjoyed a competitive advantage partly through operators' uptake of modern marketing technologies (Tomkins). National Australia Bank's top derivatives trader in pricing and dealing is reported to travel as far west as Quilpie in western Queensland, where wool is the chief industry, to meet clients and make deals (Thomas).

Share-farming is a standard response to risk spreading. The landowner may contract out of many sources of risk, whilst the sharecropper may assume a larger proportion of risk, depending on the terms of their contract. Otsuka, Chuma and Hayami analysed the choice and efficiency of land and labour contracts under various conditions. They found, among other conclusions, that fixed-rent contracts will be chosen where contract terms are difficult for landowners to enforce, and sharecroppers are risk neutral. In New Zealand, on the other hand, sharemilkers take out proportionate contracts, in conditions of complete enforcibility but high weather variations. Allen and Lueck considered the problem of contract design for share-farm agreements, where many important parameters are unobservable. They used data from Nebraska and South Dakota to show that share-of-crop contracts are more likely when the probability of sharecroppers' adversely affecting soil quality is high and crop division costs are low. In the latter cases, current production risk is shared, in order to ameliorate other potential risks.

3. Summary and Conclusions

This paper has maintained the traditional distinction between management strategies that cope with external uncertainty and those that protect the structure of the firm. Particular stress was placed on the formulation of a risk management plan whether it be explicit or implicit. All managers react to the circumstances around them. In this context, risk aversion merely indicates that managers make decisions that protect their interests; some may be very conservative but others may well seek gains though at higher levels of risk.

In a dynamic world new risks may be introduced and some risk management strategies may have unexpected results. New production risks may be substituted for old, when chemical resistance is induced in insect pests; new production risk may be substituted for financial risk when, for example, ecological risk is enhanced by inappropriate management of ecosystems; or financial risk substituted for production risk in the case of capital investment in irrigation systems where water supply subsequently fails.

Risk management strategies adopted by farm managers owners/will be in accord with their personal preferences for risk. Research suggests that the majority of people are risk averse, and manage their resources accordingly. However, as risk management becomes more complex, new systems must be developed to enable managers to meet their goals. The development of personal computers promises to provide a means of analysis, provided researchers are able to devise systems which encompass actual farm firm situations. Managers/owners must make risk management decisions continuously. Actions will depend on present perceptions and events further out will be discounted heavily in todays terms. Eventually, long term risk events will come to account.

References

ABARE (AUSTRALIAN BUREAU OF AGRICULTURAL AND RESOURCE ECONOMICS) (1990), '*Wool Price Stabilisation*, Submission to the Wool Review Committee, AGPS,

ALLEN, D. and LUECK, D. (1992), 'Contract Choice in Modern Agriculture', *Journal of Law and Economics* 35(2), 397-426.

APLAND, J., McCARL, B. and MILLER, W. (1980), 'Risk and Demand for Supplemental Irrigation: A Case Study in the Corn Belt', *American Journal of Agricultural Economics* 62, 142-145.

AULL-HYDE, R., GEMPESAW, C.M. and TADESSE, S. (1994), 'A Strategic Planning Model for Agricultural Production', *Mid-Atlantic Journal of Business* 30(1), 81-96.

BARRY, P.J. and FRASER, D.R. (1976), 'Risk management in primary agricultural production: Methods, distribution, rewards, and structural implications', *American Journal of Agricultural Economics 58, 286-295.*

BARRY, P.J., HOPKIN, J.A. and BAKER, C.B. (1988), *Financial Management in Agriculture*, 4th ed., Interstate Printers and Publishers, Danville, Illinois.

BOGGESS, W.G., ANAMAN, K.A. and HANSON, G.D. (1985), 'Importance, causes and management responses to farm risks: Evidence from Florida and Alabama', *Southern Journal of Agricultural Economics' December, 105-116.*

BREIMYER, H.F. (1993), 'At Risk in Agriculture: Conservation Measures and a Political Principle', *Challenge* 36(5), 62-64.

BRIGGS CLARK, J., COLLINS, D., MENZ, K. and JOHNSON, B. (1984), Regional Analysis of Irrigation Water Pricing Policy and Water Use Efficiency, Working paper, BAE, Canberra.

BROOKFIELD, J.F.Y. (1991), 'Molecular Evolution: the Resistance Movement', *Nature* 350(Mar), 107-108.

BURT, O.R. and STAUBER, M.S. (1971), ' Economic Analysis of Irrigation in a Subhumid Climate', *American Journal of Agricultural Economics* 53, 33-46.

CASWELL, M.F. and ZILBERMAN, D. (1990), 'Managing California's Water in the Long Run', *Contemporary Policy Issues* 8(4), 92-105.

CLAUS, R.J., LARGE, D.W. and CLAUS, K.E. (1987), 'Irrigated Agriculture: Economic, Environmental, Disposal and Legal Problems', *Appraisal Journal* 55(3), 406-418.

CLINE, W.R. (1991), 'Scientific Basis for the Greenhouse Effect', *Economic Journal* 101(407), 904-919.

COLLINS, R.A. and BARRY, P.J. (1986),'Risk analysis and single index portfolio models: An application to farm planning', *American Journal of Agricultural Economics* 68(1), 152-161.

CRANE, L.M. and LEATHAM, D.J. (1993), 'Profit and Loss Sharing in Agriculture: An Application of Islamic Banking', *Agribusiness* 9(4), 403-412.

CRANE, L.M. and LEATHAM, D.J. (1995), 'External Equity Financing in Agriculture via Profit and Loss Sharing Contracts: A Proposed Financial Innovation, *Agribusiness* 11(3), 223-233.

CSIRO (1992), *Climate Change Scenarios for the Australian Region,* Climate Impact Group, CSIRO, Canberra.

DINAR, A. and LETEY, J. (1991), 'Agricultural Water Marketing, Allocative Efficiency and Drainage Reduction', *Journal of Environmental Economics and Management* 20(3), 210-223.

DOHERTY, J. and STALLMAN, A. (1992), *Land Management Options for a Salt-Affected Catchment on the Darling Downs,* QDPI, Brisbane.

DOVER,M.J. and CROFT B.A. (1986), 'Pesticide Resistance and Public Policy' *Bioscience* 36(Feb), 78-85.

EIDMAN, V.R. (1994), 'Risk management in Agriculture', *Proceedings of Risk Management in Australian Agriculture Conference,* University of New England, Armidale.

EINHORN, C.S. (1994), 'Commodities Corner: Hold on to your Seat', *Barrons* 74(33), MW11.

FARUQUI, A. (1989), 'The Role of Demand-Side Managemnt on Pakistan's Electric Planning', *Energy Policy* 17(4), 382-395.

FENWICK, T.D. (1990), Water Allocation and Transfer Practices in Queensland, paper presented at the Transferability of Water Entitlements Seminar, Centre for Water Policy Research, UNE, Armidale.

FOWLER, A.M. and HENNESSY K.J. (1995), 'Potential Impacts of Global Warming on the Frequency and Magnitude of Heavy Precipitation', *Natural Hazards* 11, 283-303.

GABRIEL, S.C. and BAKER, C.B. (1980), ' Concepts of business and financial risk', *American Journal of Agricultural Economics* 62, 560-564.

GODDEN, D. (1992), 'Socioeconomic Impacts of Climate Change on Agriculture: an Australian Perspective', *Proceedings of the National Agricultural and Resources Outlook Conference,* ABARE, Canberra.

HALL, N.H., ANANDAJAYASEKERAM, G., BARRY, G. And COLLIMORE, C. (1992), 'Greenhouse Gas Reduction: Implications for Australian Agriculture', *Proceedings of the National Agricultural and Resources Outlook Conference,* ABARE, Canberra.

HARDAKER, J.B., PANDEY, S.P., and PATTEN, L.H. (1991), 'Farm planning under uncertainty, a review of alternative programming models', *Review of Marketing and Agricultural Economics* 59(1), 9-22.

IAC (INDUSTRIES ASSISTANCE COMMISSION) (1978), *Rural Income Fluctuations,* Report No. 161, AGPS, Canberra.

JARRETT, I., and BROWN, H. (1995), 'Commodity marketing board modernisation: The Queensland experience', *Review of Marketing and Agricultural Economics 63, 419-425.*

JOHNSON, R.W.M. (1992), 'Risk and the Farm Firm: A Corporate Finance View', *Review of Marketing and Agricultural Economics* 60(1), 9-21.

JOHNSTON, T. (1994), 'Where to now for CALM?', *Australian Farm Journal* April, 8-12.

JUST, R.E. and ZILBERMAN, D. (1988), 'The Effects of Agricultural Development Policies on Income Distribution and Technological Change in Agriculture', *Journal of Development Economics* 28(2), 193-216.

KANAZAWA, M. (1993), 'Pricing Subsidies and Economic Efficiency: The US Bureau of Reclamation', *Journal of Law and Economics* 36(1), 205-234.

KAYE, L. (1989), 'Subcontinent: The Wasted Waters; Himalayan Plunder; Resources and Rights; Buyers' Market', *Far Eastern Economic Review* 143(5), 16-22.

KIM, C.S., MOORE, M.R., HANCHAR, J.J. and NIESWIADOMY, M. (1989), 'A Dynamic Model of Adaptation to Resource Depletion: Theory and an Application to Groundwater Mining', *Journal of Environmental Economics and Management* 17(1), 66-82.

KININMONTH, W. (1994), 'Climate Variability and Agricultural Risk Management', *Proceedings of Risk Management in Australian Agriculture Conference,* University of New England, Armidale.

KNAPP, K.C. and DINAR, A. (1988), 'Production with Optimum Irrigation Management Under Saline Conditions', *Engineering Costs and Production Economics* 14(1), 41-46.

KYLE, S. (1993), 'The Relationship between Farm Production Risk and Off-farm Income', *Agricultural and Resource Economics Review* October, 179-188.

MADDEN,B.J. and MALCOLM, L.R. (1996), 'Deciding on the worth of agricultural land', *Review of Marketing and Agricultural Economics* 64,152-165.

MAHLMANN, K. (1990), 'CBOT Handles Agricultural Futures as Carefully as All the Others', *Financier* 14(1), 25-27.

MANI, G.S. (1985), 'Evolution of Resistance in the Presence of Two Insecticides', *Genetics* 109(Apr), 761-783.

MARTIN, S. (1996), 'Risk Management Strategies in New Zealand Agriculture and Horticulture', *Review of Marketing and Agricultural Economics* 64(1), 31-44.

MENDELSOHN, R., NORDHAUS, W.D. and SHAW, D. (1994), 'The Impact of Global Warming on Agriculture: A Ricardian Analysis', *American Economic Review* 84(4), 753-771.

MILLER, M.L., BROWN, P.L., DONOVAN, J.J., BERGATINO, J.L., SONDERGGER, J.L. AND SCHMIDT, F.A. (1981), 'Saline Seep Development and Control in the North American Great Plains - Hydrological Aspects', *Agricultural Water Management* 4, 115-141.

MOORE, T.G. (1987), 'Farm Policy: Justifications, Failures and the Need for Reform', *Federal Reserve Bank of St. Louis Review* 69(8), 5-12.

MUES,C. (1990), 'An Analysis of Marketing Options for Cotton in Australia', *Australian Cottongrower* 10(3), 94-101.

MUIRHEAD, W.A., STAPPER, M., SMITH R.C.G. and WHITE, R.J.G. (1985), 'The Development and Evaluation of a Computer-Based Management System for Irrigated Wheat', *Proceedings of 3rd Australian Agronomy Conference,* Australian Society of Agronomy, Hobart.

MUNCK, L. (1991), 'Man as Selector - A Darwinian Boomerang striking through Natural Selection', in J.A. Hansen (ed.), *Environmental Concerns,* Elsevier Applied Science, London.

NICHOLAS, S. and HORTON, J. (1994), *Farm Surveys Report, 1994,* ABARE, Canberra.

OGGLETHORPE, D.R. (1995), 'Sensitivity of Farm Plans under Risk-Averse Behaviour - A Note on the Environmental Implications', *Journal of Agricultural Economics* 46(2), 227-232.

OTSUKA, K., CHUMA, H. and HAYAMI, Y. (1992), 'Land and Labour Contracts in Agrarian Economies: Theories and Facts', *Journal of Economic Literature* 30(4), 1965-2018.

PATRICK, G.R., WILSON, P.N., BARRY, P.J., BOGGESS, W.G. and YOUNG, D.L. (1985), 'Risk Perceptions and Management Responses: Producer-Generated Hypotheses for Risk Modelling', *Southern Journal of Agricultural Economics* 17, 231-238.

PATTERSON, I. and SHELTON, L. (1995), 'Forward Marketing under Trial, *Queensland Country Life,* 26 October.

PEARMAN, G., MANTON, M. and WALKER, B. (1995), 'Climate Change Science', Briefing Notes to House of Representatives Environment Committee, Canberra.

PETERSON, D. and MOON, L. (1994), *Farm Surveys Report, 1994,* ABARE, Canberra.

PITTOCK, A.B. (1995), 'How Dangerous is Climate Change?' *Proceedings of the Inaugural Ecological Economics Conference,* ANZSEE and CARE, University of New England, Coff's Harbour.

POSTEL, S. (1986), 'Needed: A New Water Policy', *Challenge* 26(6), 43-49.

QCL (Queensland Country Life) (1995), 7 December: 3.

RALSTON, D.E. and BEAL, D.J. (1994), 'Report of Farm Finance Survey: The Financial Planning and Risk Management Practices of Farmers on the Darling Downs', Working Paper No. 94-9, Faculty of Commerce, University of Southern Queensland, Toowoomba.

RAMIREZ, A. (1988), "A Warming World: What Will It Mean?', *Fortune* 118(1), 102-107.

ROSEN, M.D. and SEXTON, R.J. (1993), 'Irrigation Districts and Water Markets: An Application of Cooperative Decision-Making Theory', *Land Economics* 69(1), 39-53.

ROSENBERG, N.J. and SCOTT, M.T. (1994), 'Implications of Policies to Prevent Climate Change for Future Food Security', *Global Environmental Change* 4(1), 49-62.

SCOTT, B.J. (1994), 'Farmers' Risk Management Attitudes, Perceptions and Practices', *Proceedings of Risk Management in Australian Agriculture Conference,* University of New England, Armidale.

SCSC (STANDING COMMITTEE ON SOIL CONSERVATION) (1982), 'Salting of Non-Irrigated Land in Australia', Report by Working Party on Dryland Salting in Australia for Standing Committee on Soil Conservation.

SHAW, R.J. (1992), 'Guidelines for Decision-Making on Utilisation of Salt Affected Soils in Summer Rainfall Areas', Paper presented at International Symposium of Strategies for Utilising Salt Affected Lands, Bangkok.

SIMMONS, P., POULTER, D. and HALL, N.H. (1991), 'Management of Irrigation Water in the Murray-Darling Basin', Discussion Paper 91.6, ABARE, Canberra.

SONKA, S. (1992), 'Socioeconomic Impacts of Climate Change on Agriculture: Decision Perspectives', *Proceedings of the National Agricultural and Resources Outlook Conference,* ABARE, Canberra.

SONKA, S. And PATRICK, G.F. (1984), 'Risk management and decision making in agricultural firms' in BARRY, P.J. (Ed) *Risk Management in Agriculture,* Iowa State University Press, Ames, Iowa.

TEAGUE, M.L., BERNARDO, D.J. and MAPP, H.P. (1995), 'Farm-Level Economic Analysis incorporating Stochastic

Environmental Risk Assessment', *American Journal of Agricultural Economics* 77(1), 8-19.

THOMAS, T. (1995), 'Westpac First Again in Risk Management', *Business Review Weekly* 13 November, 76-78.

TOMKINS, R. (1994), 'Business Management - Colly Farms', Paper presented at Sheep and Wool Refresher Course, QDPI, Gympie.

TORELL, L.A., LIBBIN, J.D. and MILLER, M.D. (1990), 'The Market Value of Water in the Ogallala Aquifer', *Land Economics* 66(2), 163-175.

TREWIN, R., PETERSON, D., CHAMBERS, R. and MOON, L. (1992), 'Managing Farm Risk', *Proceedings of the National Agricultural and Resources Outlook Conference*, ABARE, Canberra.

TSUR, Y. and GRAHAM-TOMASI, T. (1991), 'The Buffer Value of Groundwater with Stochastic Surface Water Supplies', *Journal of Environmental Economics and Management* 21(3), 201-224.

WAGNER, J.E., CUBBAGE, F.W. and REDMOND, C.H. (1995), 'Comparing the Capital Asset Pricing Model and Capital Budgeting Techniques to Analyse Timber Investments', *Forest Products Journal* 45(7-8), 69-77.

WAHLQUIST, A. (1995), 'Wool Snagged in a Slump', *The Bulletin*, 28 November: 82-83.

WOOLWORTHS LTD. (1995), *1995 Annual Report*, Woolworths, Sydney.