WOOL ON THE BRINK - THE PUBLIC COST OF UNDERWRITING THE WOOL MARKET[12]

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Over the last twenty years the Australian wool industry has intervened in the wool market, buying and selling substantial quantities of wool in order to "provide greater stability of wool prices at maximum sustainable levels, subject to the costs of stockholding" (AWC 1990). Despite the initial scepticism of many economic commentators, the scheme appeared to be reasonably successful throughout the 1970's and most of the 1980's. However, towards the end of that decade things began to go seriously wrong.

For the last year and a half the buffer stock bought more than half of all wool offered for sale. Stocks and debt both grew rapidly. Borrowing became difficult and in May 1990 the Government agreed to underwrite the debt. By February 1991 the scheme was in crisis. The Government has indicated that it is no longer willing to support the reserve price, regular wool sales have been suspended, and it seems likely that the scheme will be abandoned.

In this paper some tools from modern finance theory are used to look at the financing of a market stabilisation scheme by commodity backed borrowing. In applying these tools, it is necessary to consider how to value commodity stockpiles which are large enough to depress world prices. An estimate is made of the risk premium on current borrowing and of the public liability taken on by the Government. An explanation is also advanced, based on the conflict of interest between the owners of debt and equity, for the industry's reluctance to lower the price of wool.

Policy implications are drawn out for wool marketing policy and for the management of the large stocks which have been accumulated. The implications for the theory of stabilisation schemes backed by commodity credit are also discussed.

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Introduction

Over the last twenty years the Australian wool industry has intervened in the wool market, buying and selling substantial quantities of wool in order to "provide greater stability of wool prices at maximum sustainable levels, subject to the costs of stockholding" (AWC 1990).

Wool stabilisation differs in a number of respects from traditional buffer stock stabilisation schemes, such as those which have operated for other commodities like tin and rubber. The scheme is funded by a levy on wool sales (the "wool tax", collected by the Government on behalf of the industry), with no direct Government funding from general revenue sources. Accumulated funds (the Market Support Fund) are used to purchase wool and support the market when prices are low. When the Market Support Fund is exhausted, any purchases are financed by borrowing (generally from commercial sources) against the collateral of the wool stockpile. If the Market Support Fund grows too large then payments are made to growers (the fund is "revolved"). Thus wool stabilisation has some of the characteristics of a buffer fund as well as of a buffer stock. Through its reliance on borrowing, it also has some of the characteristics of commodity credit arrangements.

Compared to traditional price band stabilisation, there is much more discretion in the hands of the Australian Wool Corporation as to when to intervene. A floor price is announced annually, but the Wool Corporation has at times purchased wool when prices are above this floor. There is no clear guideline on when to sell or on the liquidation of stocks. Management of the buffer fund is also largely discretionary. The maximum level of the "wool tax" is set in legislation (Wool Marketing Act 1987), but the timing and level of repayments to growers from the fund at the discretion of the Wool Corporation and the Wool Council of Australia.

Despite the initial scepticism of many economic commentators, the scheme appears to have been reasonably successful throughout the 1970's and most of the 1980's. Price instability was judged by most observers to have been noticeably reduced. Government involvement appeared to be minimal, and the Government seemed to have avoided being drawn into wholesale subsidisation of the industry. After carefully analysing the scheme, using the Newbery and Stiglitz (1981) framework, Hinchy and Fisher (1988) cautiously concluded that the risk reduction benefits outweighed the costs.

However, towards the end of the 1980's, things began to go seriously wrong. In 1987-88 wool prices rose rapidly as stocks ran down. The Wool Corporation made the classic error of interpreting a temporary price spike, caused by a stockout, as a permanent structural shift and raised the Reserve Price to a level well above any reasonable long term expectation. The new price set off a boom in Australian wool production and a retreat by fibre users to cotton and synthetic fibres. By the end of the 1989, the Corporation began to buy heavily. Over the next eighteen months more than half of all wool offered for sale was bought by the Corporation. Stocks rose to from 9 thousand bales in June 1988 to 4.6 million bales at the end of 1990. This is more than double the previous historical peaks of 1.8 and 1.6 million bales. The buffer fund which stood initially at $1.8b on the 30th June 1989 was quickly exhausted. By the end of 1990 the fund was $2.6b in debt (Bolt, Financial Review 1991).

The industry was thrown into crisis. In May 1990 the Government intervened and used its reserve powers over the Corporation to force the Reserve Price down from 870 to 700 cents per kilogram (c/kg). However this price still proved too high, and could only be sustained by continued stockpiling. The Corporation was by this time finding it difficult to borrow on the commercial market. In May 1990 the Government finally agreed to guarantee the Corporation's debt (with a cap of $2.5 billion).

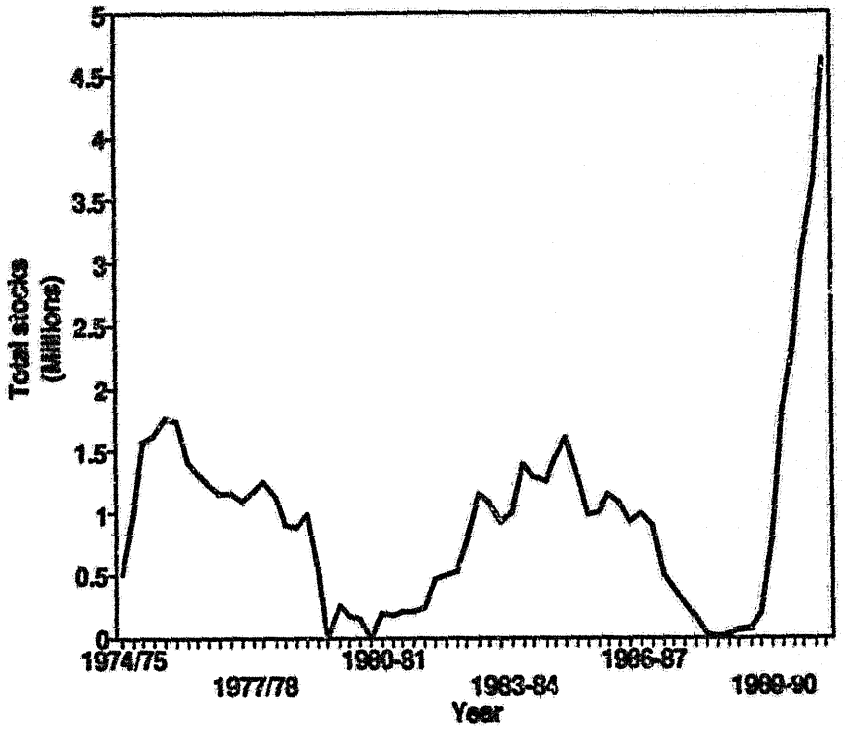

Figure 1 The Buffer Stock (bales of wool)

At present (January 1991) the future existence of the stabilisation scheme is in doubt. The industry is still committed to the current price of 700 c/kg. A variety of supply control measures have been proposed, including delivery quotas and subsidised slaughter of sheep. However, at the end of January the Minister indicated that the Government was no longer prepared to stand behind the current price, and all official wool sales were suspended. It is widely expected that the end of the wool stabilisation scheme will be announced shortly.

How should these events be interpreted? It is well known that a simple price band buffer stock stabilisation scheme must eventually fail, unless it is backed by infinite storage capacity and infinite wealth to purchase stocks (Townsend 1977). Essentially, this is a variant of the familiar gambler's ruin theorems (Dubins and Savage 1965). The wealth of the buffer stock holder will undergo arbitrarily large fluctuations, both positive and negative, leading to almost certain bankruptcy. Is the wool crisis a simple tale of gambler's ruin?

This is clearly part of what has happened. However Wool Corporation borrowing is backed by commodity collateral, which complicates the gambler' ruin story. How much, and on what terms, can one expect to borrow against commodity collateral? Can borrowing put off the gambler's ruin? In considering this, one is lead to a related question. How should one value a commodity stockpile when used as collateral for a loan? The current market value of the commodity is unlikely to be appropriate, particularly if the stock is being actively used to manipulate the market price.

There is another puzzling aspect. Why has the crisis in the wool stabilisation scheme been so sudden and so extreme? In particular, why has the wool industry been so stubborn in setting and

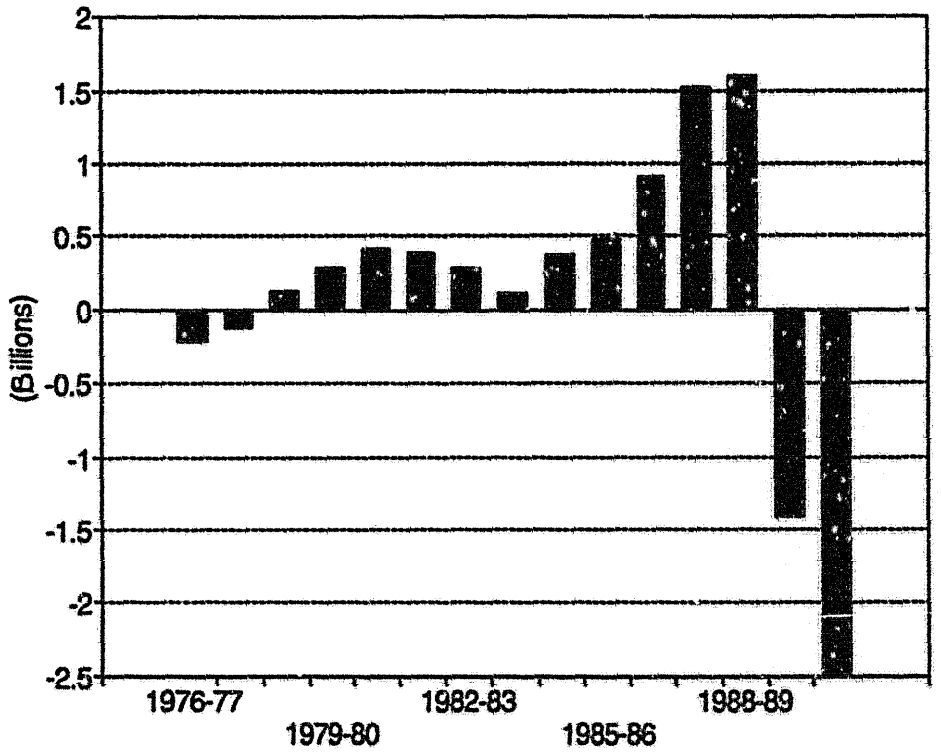

Figure 2 The Buffer Fund (Market Support Fund net of Wool Stocks)

maintaining a price which has brought the scheme to its knees?

The theory of speculative attacks on buffer stocks (Salant 1983, Wright 1988) provides some explanation for a sudden market contraction. If it appears that a price support arrangement is under threat then it becomes dangerous for market participants to hold stocks, for if the price support collapses then stockholders will take a capital loss. Under some circumstances there comes a point when private stock holding suddenly contracts discontinuously. However, by its very nature, this is a one-off event. It is difficult to believe that the continuing imbalance in the wool market over the past eighteen months is due to speculators and other private stock holders continuously running down their stocks below normal levels because they fear a price collapse.

There is another explanation which must be considered. Watson (1990) has pointed out that the 70 per cent increase in the Reserve Price over the two years 1987-88 and 1988-89 coincided with administrative changes that gave woolgrowers more power in setting the Reserve Price. To understand the course of events, it is useful to look in more detail at the role of the Government in the scheme. From 1974 until 1987 the Minister set the Minimum Reserve Price on an annual basis, after taking the advice of both the industry and his own economists. The maximum level of the Wool Tax was set in legislation. The Minister authorised industry borrowing, but did not explicitly underwrite the industry debt (there is no doubt, though, that the Government was seen to stand to some degree behind the scheme, and influenced the terms on which the Wool Corporation was able to borrow). In 1987 the Government sought to distance itself from the scheme. This was part of a general policy of reforming agricultural Statutory Marketing Authorities to make them more commercial and less creatures of the Government. It was argued that wool marketing is an industry

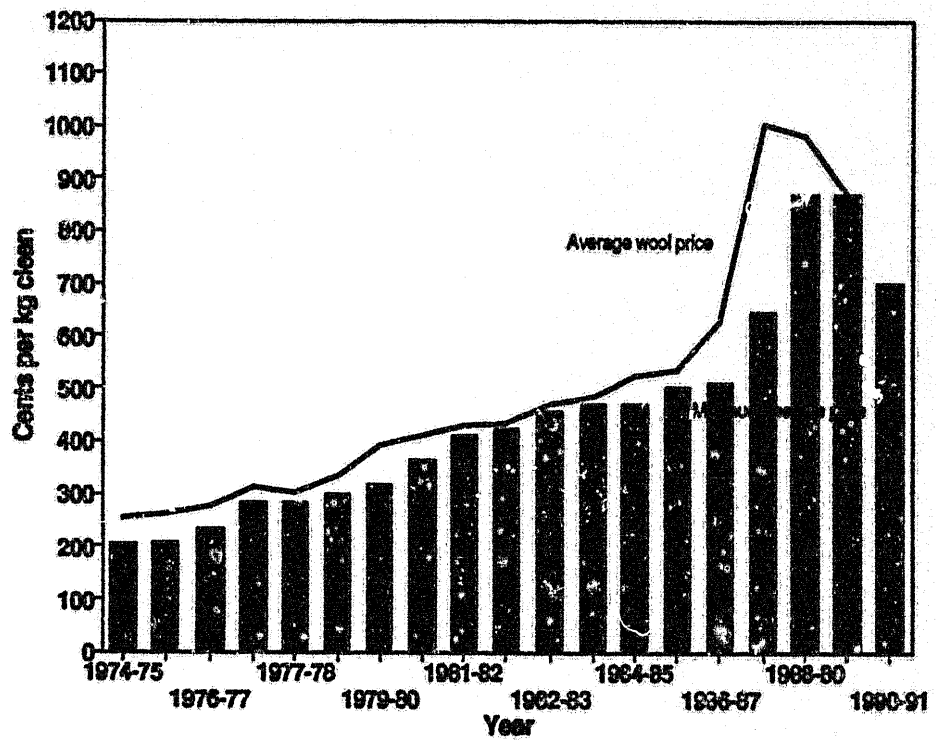

Figure 3 **The Price of Wool, and the Reserve Price**

matter, that intervention in the market is funded by the industry, and that wool is an export industry with minimal direct impact on Australian consumers. Benefits of intervention in the wool market were internalised within the industry, and the industry had all the incentives to make correct commercial decisions. As part of this reform, the Government passed to the industry the right to set the Minimum Reserve Price. The Minister retained only a last resort right to give a formal written directive to the Corporation. This development met with widespread support by the industry, but was viewed with some scepticism by other observers. These sceptics were not surprised when the new powers were immediately used to substantially raise the reserve price.

The wool stockpile is funded by a combination of equity (the accumulated growers' contribution to the Market Support Fund net of funds "revolved" back to growers), and of debt. As is usual, the equity holders are the residual owners of the assets after debt obligations are repaid, and control rests with the equity holders through managers (the Wool Corporation) who act on their behalf. It is well known that there is a potential conflict of interest between debt and equity holders in any enterprise. As the level of debt financing increases and the value of equity declines the temptation grows for risky policies to be implemented which, if they are successful, yield benefits to the equity holders but which, if they fail, risk insolvency. For this and other reasons it is normal for the cost of borrowing to increase with the level of debt (there is a "risk premium"), and for the lenders to exercise greater control and supervision when leverage increases.

In addition to the wool industry and its financiers, there is a third player - the Government. It can reasonably be argued that the Government has always implicitly stood behind Wool Corporation borrowing, at least to some degree. Its role can be much more clearly seen after May 1990, when

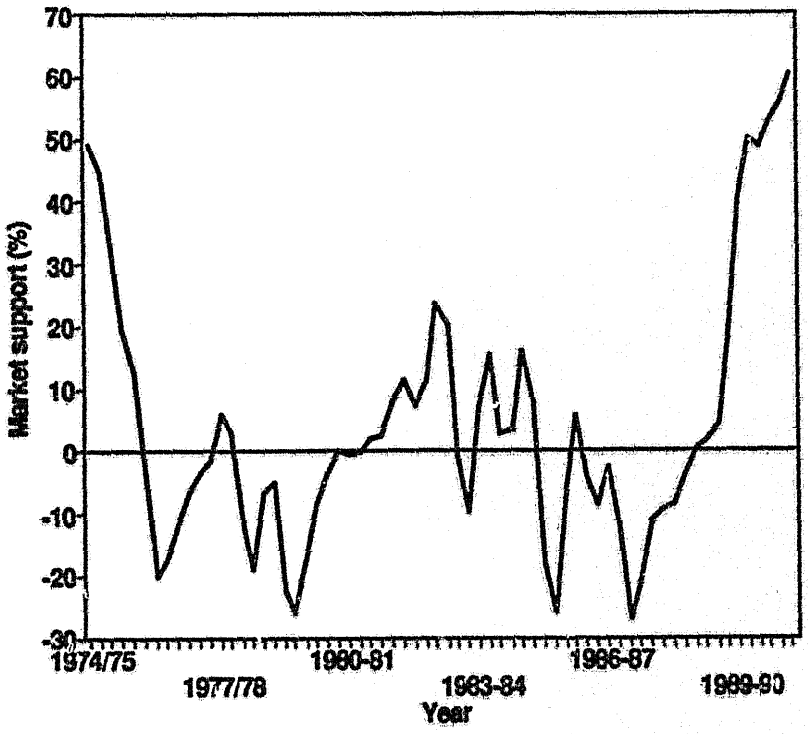

Figure 4 Market Support (purchases as proportion of supply)

it formally guaranteed Corporation borrowing for market stabilisation. The conflict of interest between equity owners and a debt guarantor is even stronger than that between equity and debt. If the industry follows a policy of over production and stock accumulation, then growers receive an immediate benefit. They are paid for their production at a (high) guaranteed price. The wool is sold, either to the trade or implicitly to the Government, and the money is in the pocket. A growing stockpile overhangs the market, driving down the underlying real price of wool. It becomes more likely that, if stock has to be liquidated (possibly under adverse market conditions), then the value of the assets may be less than the debt and the guarantee may be called. It seems unlikely that any Government cost in honouring its guarantee could be brought back to individual wool growers.

Of course current benefits of such a policy (cash in the hand) must be weighed against future costs to the industry. These costs could include the devaluation of any grower equity in the Market Stabilisation Fund (but this equity may already be minimal), and the loss of future risk reducing market stabilisation if the wool stabilisation scheme were to be dismantled. There is also the possibility of damage to long term future demand prospects for wool if processors and manufacturers invest in wool-minimising technology, product development and advertising (though it could perhaps be argued that any wool user who looks at current stocks might anticipate that cheap and plentiful wool will be available, one way or another, in the near future). There are of course many complex factors which need to be considered in managing the wool stockpile. However interest rates are high and current benefits must weigh highly against future costs, especially if some of those costs may not be borne by the industry.

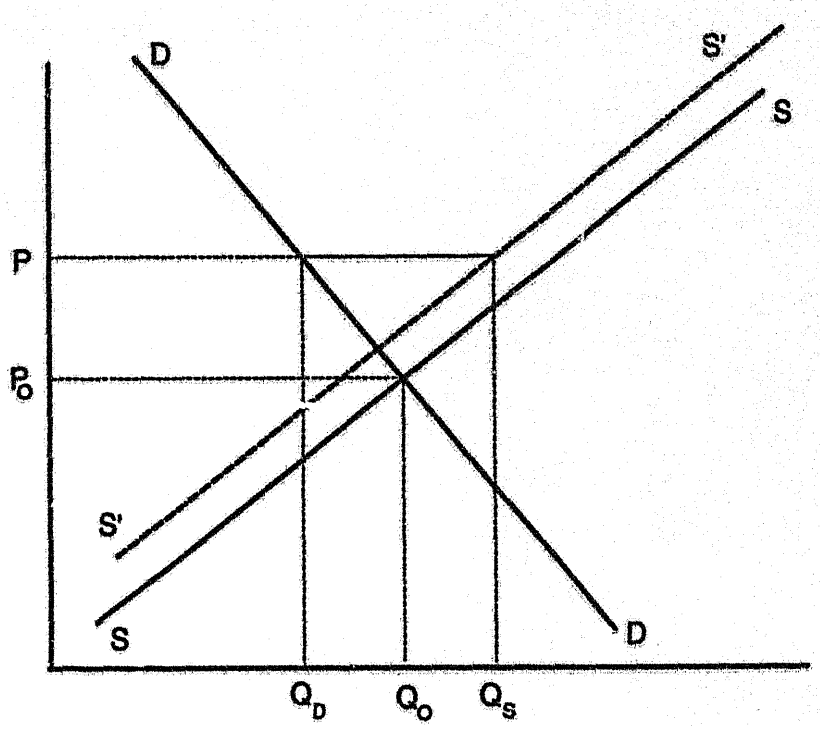

Figure 5 **Supply, demand and market support**

As debt levels rise, it is natural and normal for lenders and guarantors to seek to exercise more control in order to protect them from the growing conflict of interest between debt and equity. The decision in 1987 to place the Wool Corporation more at arms length from government seemed at the time to be a sensible reduction in government intervention, allowing the industry to manage policies whose costs and benefits were wholly internalised. In retrospect it now appears that the degree to which the Government could stand back and allow the industry to take the consequences of its actions was over estimated. The reduction in control of the Wool Corporation increased the conflict of interest between the industry and the public over the wool buffer stock and reduced the incentives of the industry to behave reasonably. The decision to underwrite Corporation borrowing sharpened the conflict of interest. It might be pointed out that in July 1989 the Corporation (with Ministerial approval) repaid to growers $210 million from the Market Reserve Fund and then immediately began to borrow, thus actively substituting publicly guaranteed debt for growers' equity. There was by now a strong need to exercise control in the public interest.

In September 1990 the Government extended the cap on guaranteed Corporation borrowing, but demanded that effective measures be taken to restrict supply. Among the measures being considered or already implemented are an increase in the wool tax from 8 to 18, and now to 25 percent, an industry levy to subsidise the slaughter of sheep, and marketing quotas. It was also announced that no further funds would be revolved into growers' hands while the buffer fund was in debt.

In this paper some tools from modern finance theory will be used to look at the financing of a market stabilisation scheme by commodity backed borrowing. Arbitrage based asset pricing

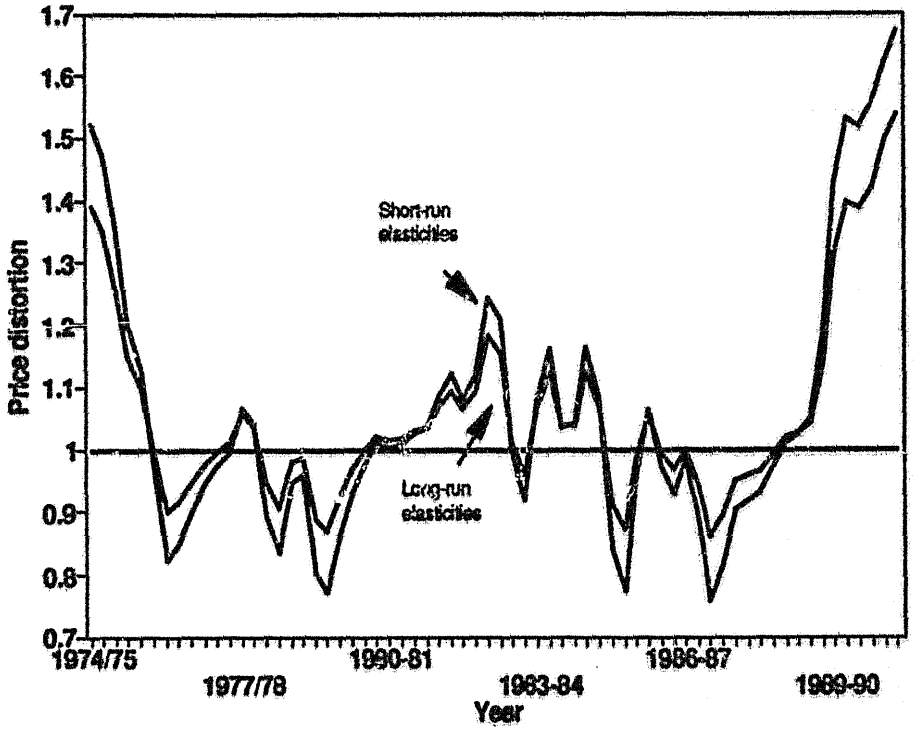

Figure 6 Impact of market intervention on price

methods for derivative assets and contingent securities will be applied to look at the cost of borrowing against a commodity stockpile. An estimate will be made of the risk premium which would be required to support current levels of borrowing by the Australian Wool Corporation, and the contingent liability taken on in underwriting the debt. In applying these tools, it is necessary to consider how to value commodity stockpiles which are large enough to depress world prices. There is a small excursion into optimal control theory to deal with this problem. Some insights gained from this analysis will then be applied to the viability of commodity stabilisation schemes backed by commodity credit. Finally some policy implications for the management of the Australian wool industry crisis will be drawn out.

Because of the rapidly changing course of events, it is necessary to specify a particular point in time at which to take a snapshot of the industry. Throughout this paper, unless otherwise specified, references to the current state of the industry will refer to the beginning of January 1991. At this time the magnitude and nature of the current crisis was apparent, but there was still considerable uncertainty, in particular as to whether or not demand would respond significantly to the reduced reserve price when sales re-opened in January. This choice of time reflects the information set which was available when key decisions were being considered by Government and industry leaders.

Intervention in the Wool Market

Wool has, since the early days of European settlement, been an important export industry for Australia. Australia still dominates world trade in the finer wool types used for apparel. Wool

supply is quite inelastic in the short run, being governed mainly by the size of the sheep flock and by seasonal conditions. Longer term supply is more elastic, and is determined in part by the biological dynamics of the sheep population. A significant amount of wool is produced on mixed sheep/cereal farms, where producers readily adjust supply over the medium to longer term. Supply is thus sensitive to the wool/cereal price ratio. Specialist wool producers located in the more arid regions are less sensitive to price. The Australian Bureau of Agriculture and Resource Economics (ABARE) has estimated supply elasticities of .2 in the short run and .6 in the long run (ABARE 1990b).

Because of its market dominance, the Australian wool industry has some degree of potential market power, especially in the short run. ABARE has estimated demand elasticities of -.85 in the short run and -1.0 in the long run (ABARE 1990b). The main influences on the demand elasticity are final consumer demand, competition from synthetic fibres, and supply response by other wool producing countries (these competitors however mainly produce coarser types of wool which are not perfect substitutes). Processing and manufacture takes time, and working stocks are held along the marketing chain.

It is generally considered that demand fluctuations are more important than supply fluctuations, particularly in the short term. In the short term, demand shocks can lead to large price fluctuations. Demand is affected by changes in fashion and by income effects. Many wool products are durable items whose purchase or replacement can be deferred. Prices are also affected by exchange rate fluctuations. Longer term price variations are also influenced by supply dynamics. Price fluctuations are moderated by stockholding, and wool prices display the characteristic price spikes caused by stockouts (Deaton and Laroque 1990), for example the Korean War wool boom of the early 1950's.

$$\frac{P}{P_0} = 1+\frac{\mu+\tau(\varepsilon+\mu-\varepsilon\mu)}{\varepsilon+\eta-\varepsilon\mu+\tau\eta}$$

$$\frac{Q_S}{Q_0} = 1+\frac{\varepsilon\mu-\tau\varepsilon\eta}{\varepsilon+\eta-\varepsilon\mu+\tau\eta}$$

$$\frac{Q_D}{Q_0} = 1-\frac{\eta\mu+\tau\eta(\varepsilon+\mu-\varepsilon\mu)}{\varepsilon+\eta-\varepsilon\mu+\tau\eta}$$

where

μ = *market support as a proportion of supply*

ε = *supply elasticity*

η = *- demand elasticity*

τ = *wool tax as a proportion of supply price*

Equation (1): Effect of market support on price, supply and demand

Since 1970, the Australian wool industry has actively intervened in the wool market with the objective of stabilising prices by purchasing wool and operating a buffer stock. An authoritative account and commentary on the origin and history of this intervention has been given by Watson

(1980,1990). There are two main mechanisms of industry intervention (although a number of new ones are being considered at present). These are open market sales or purchases by the Wool Corporation which raise or lower the market price by driving a wedge between supply and demand, and the wool tax on production. Strictly speaking, the "wool tax" should not be treated at face value, since ultimately the fund is revolved and some payment is returned to the grower. This complication will be neglected here, although it could be important in other contexts, and the tax will be treated at face value. In practice, the impact of the tax on supply is small compared with the effect of current levels of direct intervention. There is also a third effect due to the stocks which are accumulated under market support. If it is expected that these stocks will be liquidated in the near future, and if there is intertemporal substitution in demand (for example through the holding of stocks of intermediate goods), then current prices will be depressed. The effect of stocks will be considered fully in a later section. At this point it will be assumed that any stocks are effectively insulated from the market.

Under these assumptions, the state of the wool market can be represented as in Figure 5. SS is the supply of wool by Australian wool producers; DD is the world demand for Australian wool by end users (net of supply by other countries). In the absence of any market intervention, markets would clear along these supply and demand curves to give a normal price P_0 and a normal quantity Q_0. When the corporation intervenes in the market, there are two effects. The wool tax shifts the supply curve upwards to S'S'. Market support purchases drive a wedge between supply and demand, raising the price to P, increasing the quantity supplied to Q_S, and reducing the quantity demanded to Q_D.

The "normal" price and quantity are of course a convenient fiction, the intersection of supply and demand in a market free from intervention or overhanging stocks. They are useful benchmarks for comparison. Clearly both supply and demand curves will move through time under the influence of random shocks, and the normal price and quantity will fluctuate accordingly. Fortunately, the absolute values of these quantities will not be important in the present analysis, which focuses on the relative degree of market distortion.

Naturally, price formation in the wool market is in practice much more complex. Two major omissions are the demand for stocks held for convenience and production smoothing, and the role of livestock dynamics and lags in production and consumption. Of these defects, the cursory treatment of private stock holding is probably the more defensible in a model which focuses on the effect of public stock holding when these stocks are very large. The proper handling of livestock dynamics is a more difficult matter, and will be deferred for consideration in future research.

Under the assumption of linear supply and demand, explicit formulas for the effect of intervention on the market can be derived easily, and these are displayed in Equation 1. Figure 6 shows a estimates of the degree of market distortion (the price ratio P/P_0) through time under different elasticity assumptions (elasticities are as assumed in ABARE 1990b). On the basis of Figure 6 it might seem reasonable to assume that current prices are at least 50 per cent above the normal price level which would be observed in the absence of intervention.

It is, however, difficult to judge the precise effect of price support on the wool market. At the time of this industry snapshot (early January 1991) there were hopes that the traditionally stronger pattern of buying in the second half of the season would return, and that demand would finally pick up in response to the earlier reduction in the reserve price. The rather conservative assumption which will be made in this paper is that prices were supported 25 per cent above their natural level. One reason for doing this is to make it clear that the cost estimates derived later in the paper are not driven by extreme assumptions.

$$\Pi = -(1/\tau)\,\mathrm{Log}(\Phi[h_2(d,\sigma^2\tau)] + \Phi[h_1(d,\sigma^2\tau]/d)$$

where

Π = *risk premium*

d = *leverage*

$$= \frac{D\,\mathrm{Exp}(-r\tau)}{V}$$

D = *debt*

V = *value of collateral*

σ = *volatility of the collateral*

τ = *term of loan*

r = *risk free interest rate*

$$h_1(d,\sigma^2\tau) = -\frac{\sigma^2\tau/2 - \mathrm{Log}(d)}{\sigma\sqrt{\tau}}$$

$$h_2(d,\sigma^2\tau) = -\frac{\sigma^2\tau/2 + \mathrm{Log}(d)}{\sigma\sqrt{\tau}}$$

$$\Phi(x) = \frac{1}{\sqrt{2\pi}} \int_{-\infty}^{x} \mathrm{Exp}(-z^2/2)\,dz$$

Equation (2): Risk premium for debt secured by commodity collateral

It was argued above that ownership of the wool stockpile can be broken down into debt and equity. Not only does this framework lead to useful insights into the management and recent history of the scheme, it allows the analytical tools of modern finance theory to be brought to bear.

There is a well developed theory for the pricing of all types of contingent claims or derivative assets including debt, equity, and more complex financial instruments such as options and underwriting guarantees. This theory, which relies upon Ito calculus and stochastic differential equations, was originally developed by Black and Scholes (1973) in their path breaking work on option pricing, and has been comprehensively generalised by Merton (1974, 1977). The best general reference is Merton (1990, Chapters 12 and 13), which collects and updates the earlier work. The notation used below will be consistent with this reference. The basic intuition behind these methods is that equity can be viewed as a call option over the assets of the firm, and that it can be valued using option valuation techniques.

Financial assets come in many forms, typically giving the holder a contingent right to a stream of income. That is to say, the holder's rights depend on the state of the world. If a firm issues debt,

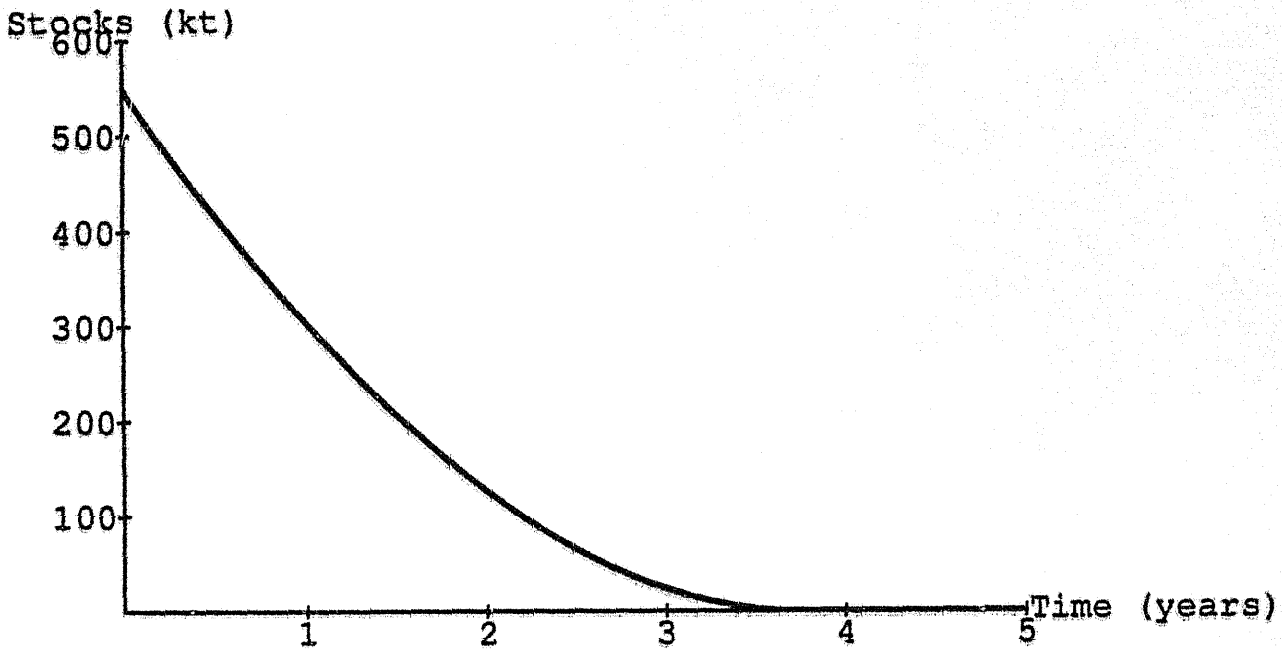

Figure 7 Optimal stock disposal

then the debt holder is entitled to a specified stream of payments (interest and capital repayments) at specified times unless the firm becomes insolvent; in this case the debt holder is entitled to the residual value of the firm (net of the costs of bankruptcy). Provided that there is no insolvency, debt holders receive a risk free fixed income stream. Equity holders on the other hand carry all the risk of day to day fluctuations in the value of the firm after debt servicing obligations have been met. Equity holders receive an uncertain stream of dividends paid at the discretion of the management. Control of the firm normaliy rests with the equity holders, either directly or through the appointment of management to act on their behalf. Debt holders exercise some control through conditions of borrowing which they impose to protect their interest in the firm. However, as the likelihood of insolvency increases, debt becomes more like equity and debt holders are likely to demand more influence on day to day management.

In applying Merton's contingent claims analysis, it will be assumed that the interest of the wool growing industry in the Market Support Fund and the wool stockpile can be treated as equity. Borrowers have first call on the value of the stocks, and growers have a residual interest in what is left after borrowers have been repaid. The market value of the collateral, that is of the wool stockpile, plays the same role as the value of the firm in Merton's analysis (see Stulz and Johnson 1985 for an application of contingent claims analysis to evaluate secured or collateralised debt).

The rate of interest required by a lender is made up of two parts. The risk free rate of interest reflects the market value of funds in the future compared with their present value. The risk premium is the additional interest rate required by the lender to compensate for the possibility of default and partial or complete non repayment of the loan. If it is assumed that lenders are risk

neutral, then the risk premium measures the expected loss from default. Default may be partial, involving only a small loss, or it might be total. The average of all possible losses, weighted by the probability of their occurrence, makes up the risk premium. Alternatively, the risk premium can be viewed as the price one would expect to pay for actuarially fair insurance against default.

When repayment is guaranteed by the Government, lenders can be expected to lend at close to the risk free rate. The risk premium is then a measure of the risk exposure transferred to the Government. Merton (1990, Chapter 12.3) shows that the risk premium is given by the formula set out in Equation 2. The main factors which affect the risk premium and the borrowing terms are the value of the collateral, the volatility of the collateral, and the term of the loan. Thus in applying this approach, two key questions must be addressed. Firstly,what is the value of the wool stockpile? Clearly it would be incorrect to value the wool at the artificial current price sustained by market support purchases. Even if market support purchases were to cease, liquidation of stocks would add to supply, reducing the price below its natural long term level. Secondly, how volatile or uncertain is the value of the wool stockpile? Both these questions will be addressed below.

Valuing stocks

The value of four million bales of wool depends on who is holding them. Three main cases can be distinguished. The stocks may be held by the industry, acting as a monopoly supplier (this is the case at present); stocks may be held by a monopolist outside the industry, who would not consider the effect on growers of his disposal policy; or stocks may be held competitively. From the perspective of a lender who is valuing stocks as collateral, it is the second case which must be considered. In the event of default, the stockpile would fall into the hands of the lender who would

$$H = e^{-rt} [\ (p-\gamma)(D(p)-S(p)) - \theta q\ ]$$

where

r = *discount rate*

t = *time*

q = *stocks (state variable)*

p = *price (control variable)*

θ = *unit storage cost (excluding interest charges)*

γ = *shadow price of stocks (costate variable, current value, not discounted)*

$D(p)$ = *demand by wool users*

$S(p)$ = *supply by wool producers*

Equation (3): Optimal disposal of stocks - the Hamiltonian

presumably dispose of it in a profit maximising way without consideration for any external costs which might be imposed on the industry through driving down prices. Fortunately this is also the easiest case to analyse.

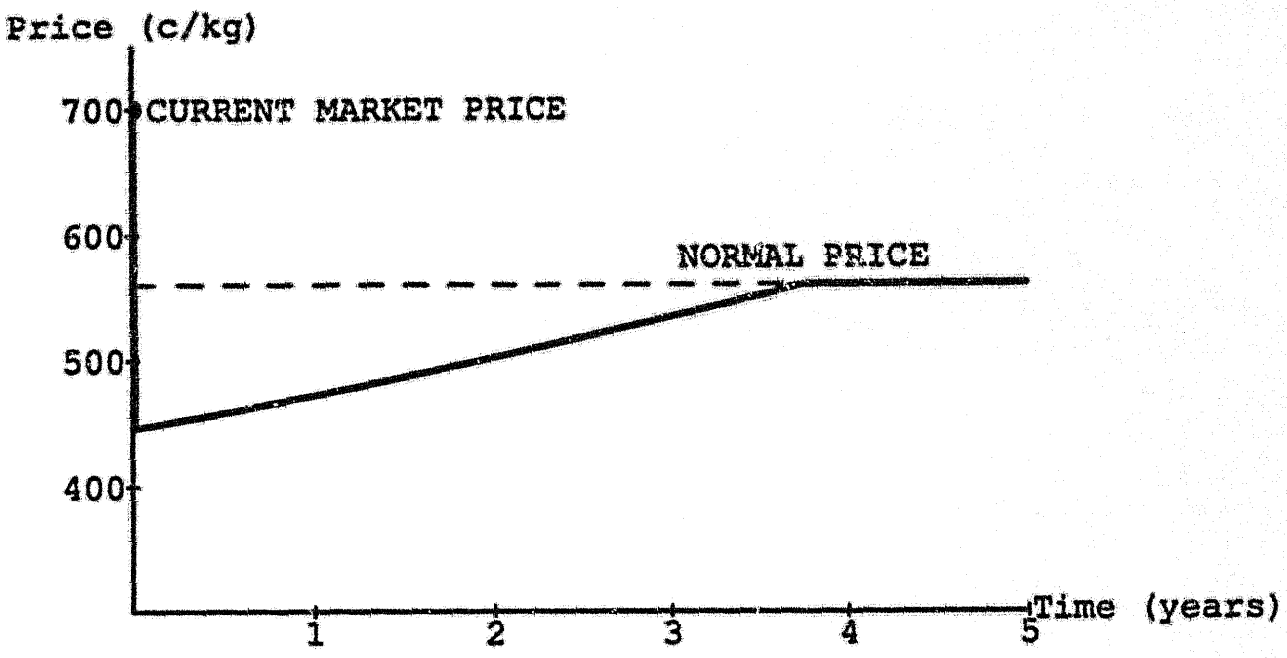

Figure 8 **Time path of prices under optimal disposal**

The value of stocks is intimately bound up with the problem of optimal disposal, since the value is just the present value of the income stream from disposal in the most profitable way. Optimal disposal must trade off two effects. If stocks are sold too quickly, then the price will be driven down. After all, the essence of the monopolist's strategy is to restrict supply. But if stocks are sold too slowly, storage costs are incurred, and the present value of the income diminishes with the discount rate. Balancing these two effects leads to an optimal time path of disposal. Stock disposal is thus an optimal control problem.

In setting up an optimal control problem, one must specify the system to be controlled, the control variables, the law of motion governing the dynamics of the system, and the payoff to be maximised (Intriligator 1971, Seierstad and Sydsaeter 1985). For the problem of optimal stock disposal, this may be done as follows. The state of the system is the level of stocks q; the costate variable is the shadow price or marginal value of stocks γ; the control variable is the market price; the law of motion is just the accounting identity which states that the change in stocks is the net sales from stock; the objective to be maximised is the present value of the net buffer stock trading profit (if the stock were being liquidated by the industry rather than by a banker then the "hidden gains and losses" calculated from the industry supply curve would be included in the objective). Both supply and demand will respond to the buffer stock disposal policy, and this response is built in to the control problem.

Formally, the control problem is specified by a Hamiltonian function, which is set out in Equation 3. The problem is to be solved as a free boundary problem (that is, the terminal time is endogenous), subject to the constraint that stocks not be negative.

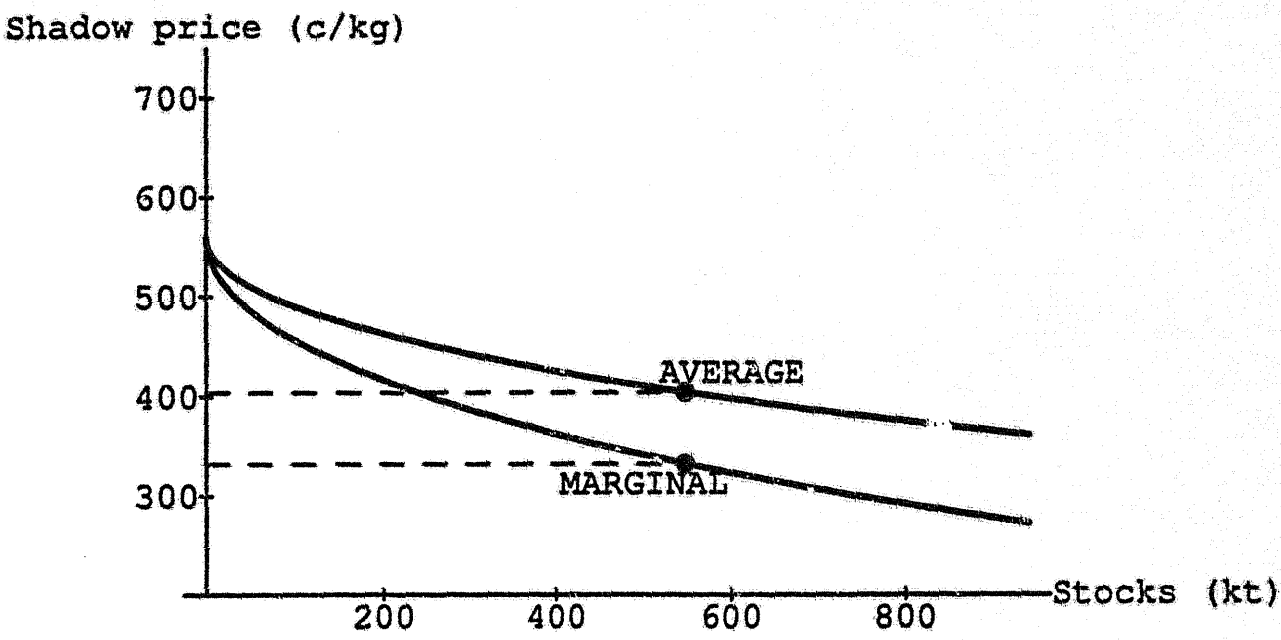

Figure 9 The shadow price of stocks

Before turning to the solution of this problem, consideration must be given to the question of uncertainty. Both demand and supply are subject to random shocks and the optimal buffer stock operator needs to take the resulting price fluctuations into account. Since the lender is risk neutral, this can be done by replacing net buffer stock profits with the expected value of net buffer stock profits in the problem set out above.

Stochastic optimal control problems are, generally speaking, very difficult to solve. Fortunately however, under the assumptions made here, the lender's collateral valuation problem is a quadratic-linear optimal control problem and we can appeal to the Theil-Simon certainty equivalence principle (Theil 1957, Simon 1956, Laffont 1989 chapter 3). This states that in solving such a problem a risk neutral optimiser will replace unknown future prices by their predicted values and then act as if there were no uncertainty. This allows us essentially to ignore the issue of uncertainty when valuing stocks, provided that the current normal price P_0 can be interpreted as the expected future normal price, that is if the price P_0 is a martingale (which is implicit in the assumptions made above). The question of uncertainty will re-emerge later in a more substantive form when the issue of collateral volatility is discussed.

The stock valuation optimal control equation leads to linear differential equations which can be solved in a straight forward manner using standard techniques. Supply and demand curves are assumed to be linear. Supply and demand elasticities are the long term elasticities estimated by ABARE (.6 and -1 respectively). The real risk free interest rate is assumed to be 9 per cent, as estimated in ABARE (1990c). This value may seem high, but monetary policy has been and

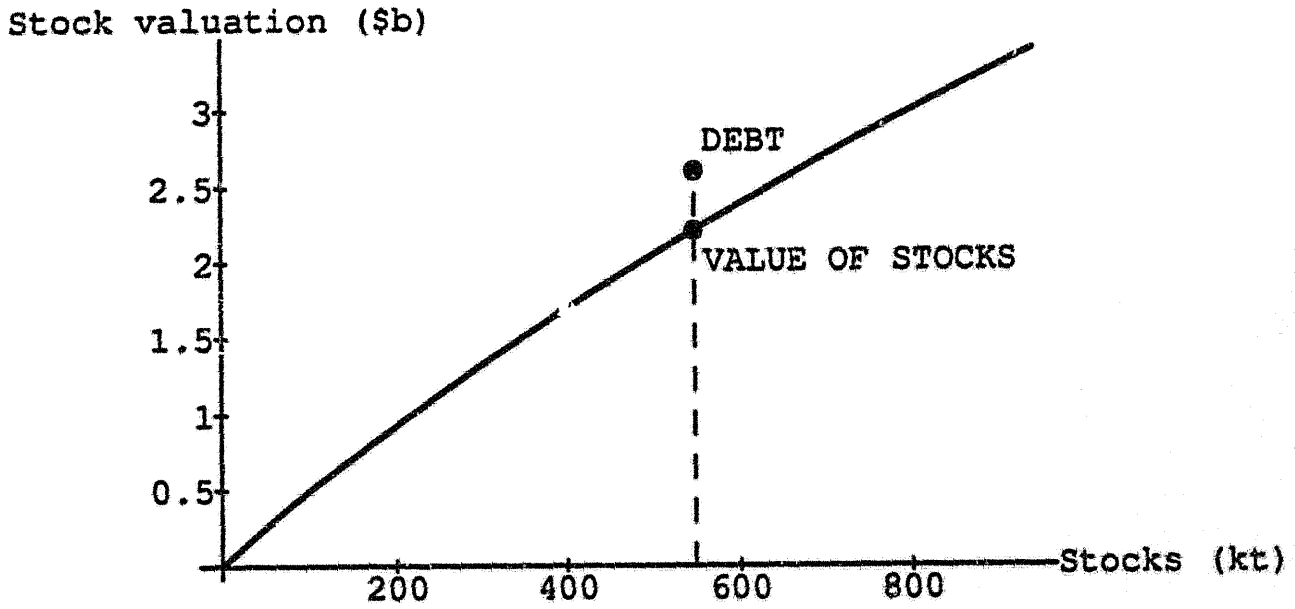

Figure 10 Debt and the value of stocks

remains tight. The cost of storage (net of interest costs) is estimated to be $20 per bale (Wool Corporation estimate), and a bale is equivalent to 119 kilograms clean. Results are shown in the following figures 7 to 10. The main conclusions to be drawn are as follows:

- if stocks passed into the control of a lender then they would be sold gradually over a period of about three and a half years;

- prices would fall from 700 c/kg to around 450 c/kg (140 c/kg of this fall is due to the cessation of market support buying, and the remaining 110 c/kg is due to stocks depressing the market); they would then steadily rise over the next three and a half years to a normal price of around 560 c/kg (assuming that underlying demand conditions do not change);

- the present shadow price of wool is, at the margin, only about 330 c/kg; that is to say, if the marginal cost of production is above this figure then a loss is being made; alternatively, if the Wool Corporation were able to act as a discriminating monopolist and dispose of some stocks outside the guaranteed price sector, then any price above 330 c/kg would look profitable;

- to value the stockpile as a whole the average shadow price (about 400 c/kg) rather than the marginal shadow price is appropriate; at this valuation the stock of 547 kt held in January 1991 would be worth about $2.21b as collateral to a lender.

$$\frac{\delta V}{V} = \frac{m\left(\frac{\gamma}{\Gamma}\right)(\eta+\varepsilon)\frac{\delta P}{P}}{\left(\frac{q}{Q}\right)} \qquad \textit{(temporary shocks)}$$

$$= \frac{\delta P}{P} \qquad \textit{(permanent shocks)}$$

where

$\frac{\delta V}{V}$ = *volatility of stockpile value*

$m = \left(\frac{P-\gamma}{\gamma}\right)$

= *markup of price over marginal cost*

$\frac{\gamma}{\Gamma}$ = *marginal value of stocks* (γ) *over average value of stocks* (Γ)

η = *minus demand elasticity*

ε = *supply elasticity*

$\frac{q}{Q}$ = *stocks* (q) *to production* (Q) *ratio*

$\frac{\delta P}{P}$ = *underlying price volatility* (*in unstabilised market*)

Equation (4): Volatility of the collateral

Given this valuation, it is possible to estimate the leverage parameter d in equation (1). Wool Corporation borrowing are around $2.6b at present (January 1991), giving a crude leverage level of about 1.17. Debt must, however, be discounted at the risk free rate. Most Corporation borrowing has been on 90 and 180 day terms, but some is being rescheduled on a longer term basis. If a term of one year is assumed, and the ABARE estimate for the risk free real interest rate of 9 percent is applied, then effective leverage is 1.12. Over all, it would seem reasonable to assume that leverage is in the range 1.05 to 1.15.

It is important to note that leverage increases as stocks accumulate. It is easy to see that, at the margin, if wool is bought into stock then the rate at which the value of stocks increases is the shadow price, while the rate at which debt increases is the market price minus the wool tax. The difference is positive at any reasonable value of the wool tax.

Volatility of the collateral

Consider now the volatility in the value of the wool stockpile as collateral. In the absence of any market stabilisation, the price of wool will fluctuate due to random supply and demand shocks. In

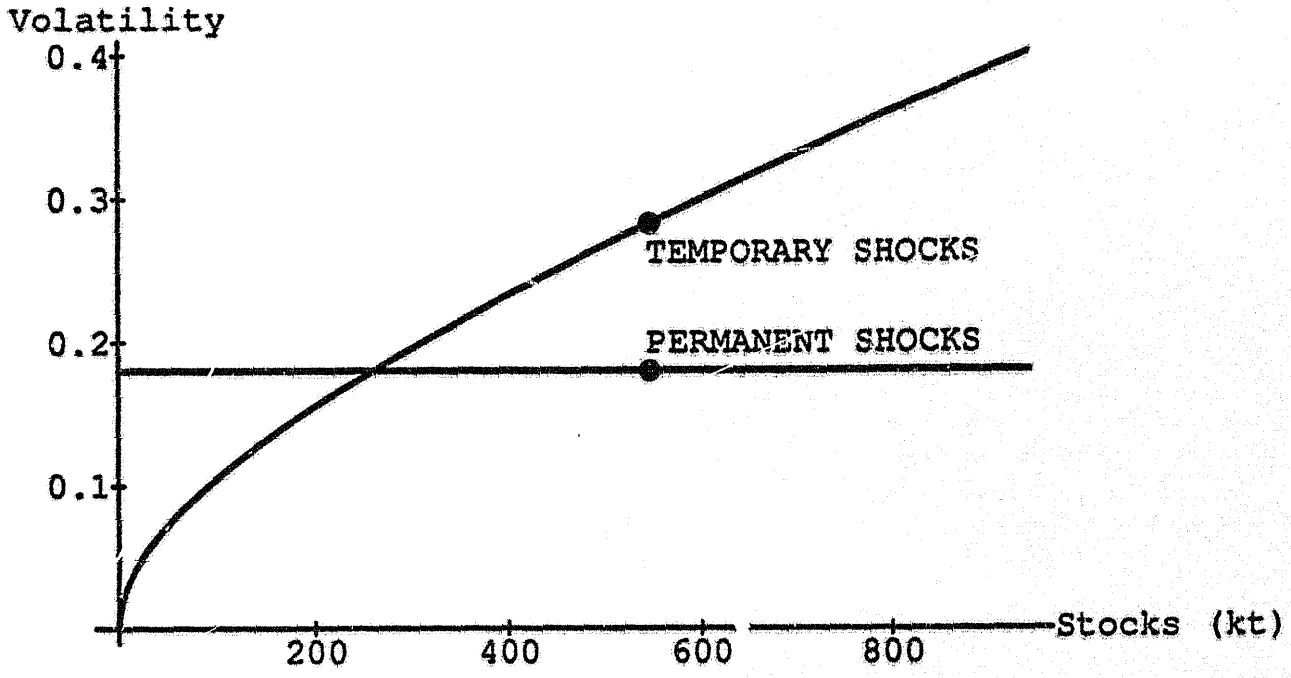

Figure 11 Volatility of the stockpile value

terms of Figure 4, the normal price P_0 and quantity Q_0 will vary randomly through time. Hinchy and Fisher 1988 estimated that the underlying price volatility in the wool market (relative standard deviation) was around .18. Market price fluctuations will naturally flow through into variations in the value of wool stocks, but the extent to which this happens depends on the nature of the price shock.

Consider first the case of temporary price fluctuations. In year 1 the price is P_1; in year 2 the price is $P_2 = P_1 + \zeta$, where ζ is a temporary fluctuation with expectation zero. The expected price in year 2 is still P_1. Thus the fluctuation ζ does not influence the shadow price of stocks, or the price at which the stockholder is willing to sell. The quantity which actually sells at this price will of course vary in an unpredictable way as the net demand shifts. A monopoly stock holder will thus respond to temporary net demand fluctuations by keeping the price steady and varying the rate of stock disposal.

Another way of coming to this conclusion is to appeal to Theil-Simon certainty equivalence. By definition, temporary price fluctuations do not change expected supply and demand. The control variable (price) depends only on expected supply and demand.

If net demand unexpectedly increases by δx, then the wealth of the stock holder increases by $\delta V = (p-\gamma)\delta x$ (Note that p is the price received, γ is the marginal cost of supplying from stock). With a little algebra it can be seen that, under temporary shocks, the volatility in the value of the stockpile is given by the formula in line 1 of Equation 4.

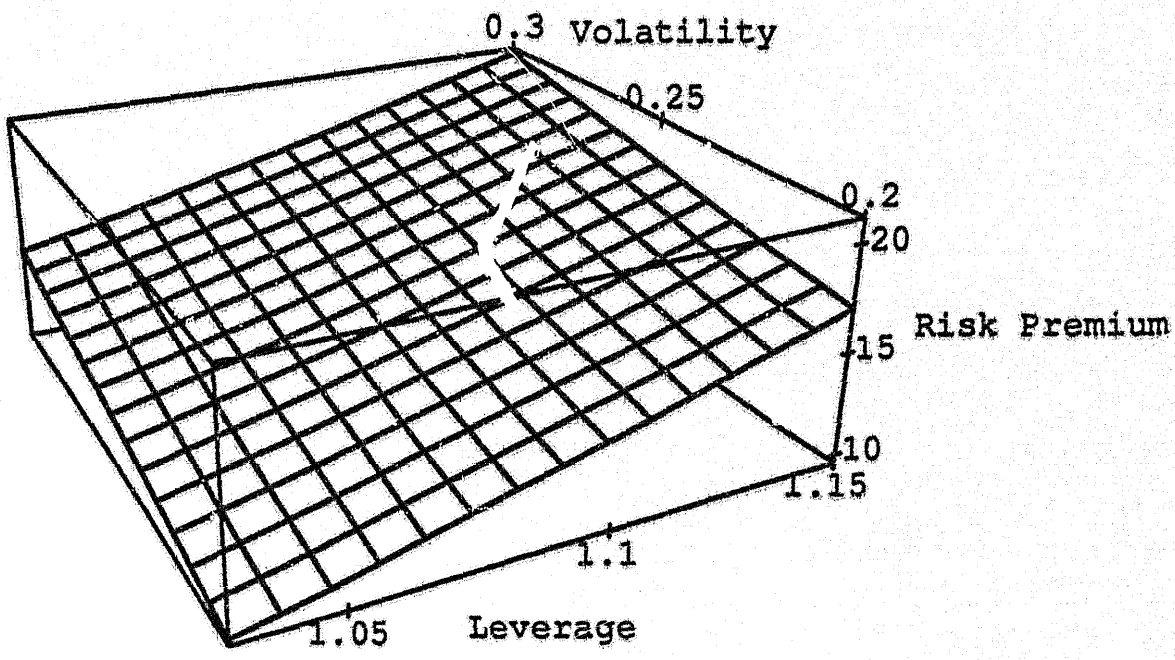

Figure 12 The risk premium

If the shocks are permanent, then the analysis is even easier. By the Theil-Simon principle, a permanent shock will change the expected prices used by the buffer stock owner in calculating an optimal disposal plan. Thus the buffer stock owner will revalue the stockpile at the new price following each shock. If the objective function (the stockpile owner's instantaneous profit function) were homogeneous in prices, then the change in the stockpile value would be proportional to the price shock, and the volatility in the value of the stockpile would be the same as the underlying price volatility. Unfortunately, the objective function is not homogeneous in prices because of storage costs, which need not move in step with commodity prices. However, storage costs (excluding interest costs), are quite small. It will be assumed here that they can be neglected in estimating the stockpile volatility.

Thus the collateral volatility depends on both the magnitude and the nature of the underlying price volatility. Figure 11, based on Equation 4, shows that the volatility appears to be in the range .2 to .3. Volatility generally increases as stocks increase.

Estimation of the risk premium

The results derived above can be summarised as follows. The Wool Corporation holds stocks of about 574 kt. In valuing this asset as collateral the current market price must be discounted firstly for the market support activity and secondly for the effect of stocks overhanging the market. On the conservative assumption that the market is supported 25 per cent above its natural level, the first adjustment is about 140 c/kg, and the second is about 110 c/kg, giving an effective average

shadow price of about 340 c/kg. Using this price the stockpile would be valued by a lender at about $2.21b.

Corporation debt is around $2.6b. This debt is a mixture of 90 day and 180 day debt and longer term finance. If an average term of around one year is assumed (this is also a conservative assumption), then the Corporation's leverage would appear to be in the range 1.05 to 1.15 (it is certainly greater than one). Using this information it is possible to calculate the risk premium which one would expect to apply to this debt were it not underwritten by the Government (see Figure 12).

It is not possible to be very precise, because the risk premium varies quite considerably over the assumed range of the parameters. On the basis of Figure 12, any figure between 10 and 20 per cent would seem to be defensible. These are quite large numbers. On a debt of $2.6b the annual expected cost of the Government guarantee would be, in present value terms, about $370m (see the calculation below). This implicit assistance to the industry might be compared with the net wool tax (contributions minus repayments) paid by the industry of $33m in 1989-90.

Policy implications for the wool industry

The starting point for any consideration of policy must be the facts of the current situation. The wool industry has a high level of debt, high leverage and consequently a very high real cost of borrowing. Stock holding is very expensive for the industry, although the true cost of stock holding is hidden by the Government guarantee on the Corporation debt. A further increase in stocks must increase the level of debt. Further more, additional stocks will increase leverage, leading to a higher risk premium and a higher cost of stock holding both for new and existing stocks. Only a small increase in leverage is needed to cause an explosive increase in these costs. At present the costs of excessive stock holding is concealed from the industry and passed on to the public sector as a contingent liability. A contingent liability may not appear to some as a real cost but recent Australian experience, particularly in Victoria, illustrates that the truth is otherwise.

The wool industry is committed to a high price policy which many observers believe can only be sustained by continued purchases for stock. A number of supply control measures are at present being considered, but unless they work quickly and effectively stocks must continue to grow. The Australian Bureau of Agriculture and Resource Economics has forecast that stocks will increase to 6 million bales by the end of 1991-92 (ABARE 1990d), with substantial additional stocks being held on farm. If this wool is bought into stock at anything like the current price then the implications for the true cost of borrowing are alarming.

Some observers have called recently for the dismantling of the Wool Reserve Price Scheme and a return to market clearing conditions (Stoeckel et al. 1990). It is certainly difficult to see the industry continuing on its current course for much longer. The state of the wool market is widely seen as a wool industry problem which must be solved by the industry. But is it really an industry problem any longer?

Some light can be thrown on this issue by a simple calculation of the true value of the growers' equity in the current stockpile. The main tangible asset of the Wool Corporation is its wool, which was valued above at $2.21b. However there is a liability (nominally $2.6b) to lenders secured against this asset, and when this liability is deducted the net value of the growers' equity may be quite small. The correct way to value the Corporation's debt is to discount it at the risk adjusted rate. Using an upper bound risk premium of 20 percent, plus a risk free rate of 9 percent, and assuming an average term of one year, the current value of the debt obligation is about $2.02b.

The value of the industry's equity in the stock pile is the residual, around $195m. The industry's equity is small but positive because there is some possibility of trading out of the negative position, repaying the debt, and realising a profit. If a lower bound on the risk premium were used in this calculation (say 10 per cent instead of 20 per cent), then the industry's equity would be even lower. The industry owns, after debt obligations and real borrowing costs, virtually none of the stockpile. By a similar calculation the public liability is the present value of obligations to lenders (discounted at the risk free rate), minus the expected value of the stocks in default. This amounts to about $370m.

There is thus a severe "moral hazard" problem in leaving wool policy in industry hands. If industry policies were to devalue the stocks or increase the debt secured against those stocks, then the cost to the wool industry would be negligible. At the worst its equity of $195m could be wiped out. Who does own the wool stockpile? By borrowing against it, the industry has passed virtually all of its interest in the asset to its lenders. Once the debt is underwritten, the lenders no longer care what happens to the asset. The lenders' interest has been passed on to the guarantor. Thus it can be argued that the stockpile should be managed not in the industry interest but in the public interest. Presumably this implies that stocks should be liquidated in a time optimal fashion using methods which are similar to those of this paper.

The Wool Act 1987 states that the objective of the Corporation is to "increase the commercial returns to Australian woolgrowers." If industry equity in the stockpile were substantial, then this objective might be appropriate for managing the stockpile, but under current circumstances it is not. Consider, for example, the proposal that current stocks should be quarantined from the market. Taken to its limit such an approach is equivalent to destruction of stocks (which removes them permanently from the market). This policy would probably be in the industry interest, since proceeds from selling stocks would go almost entirely to lenders and not to the industry, and stock disposal would depress prices. It would not however be in the public interest. The wool in the stockpile is not valueless. Its economic value, even at the margin, is around 330c/kg. Destruction of this asset, or failure to use it in the most profitable way, would not be in the public interest.

The wool industry has already received substantial assistance through higher prices on current and previous production. To manage stocks other than in a socially optimal manner should be recognised for what it is - additional assistance to the industry.

To summarise, there are three main points which emerge from this analysis. First, any further stock accumulation and borrowing appears unwise. Any benefits from stock holding (for example through income stabilisation and risk reduction) must be assessed as small when compared with the high costs of stock holding. Second, wool policy is no longer an industry matter. There is a significant risk that the debt guarantee will be called, at great public expense, and the wool industry does not have any incentive to manage stocks in the public interest. Indeed, to do so would be contrary to the Corporation's statutory obligations. Third, no matter what happens to industry arrangements in the coming months, the stocks will still be there and stock management is the real policy issue. Optimal disposal of stocks would be in the public interest.

Implications for the theory of commodity price stabilisation

I return now to the question raised at the beginning. Can a commodity stabilisation scheme avoid the gambler's ruin by borrowing secured against stocks? At first sight the answer suggested by theory may seem to be a partial yes (despite the experience of the Australian wool industry), especially if real interest rates are low and the risk premium can be kept very small. If borrowing costs are low then the extent to which a grower levy or a fixed government funding commitment

can support stock acquisition will be much greater than it would be without borrowing. Ultimately the gambler's ruin will occur, but the time to ruin will be greater by several orders of magnitude, and the likelihood of ruin in a given time frame will be much less.

Is it possible to arrange finance so that the risk premium remains small? Merton's formula shows that the risk premium grows with leverage but declines with the term of the loan. Long term financing can off-set the growth in the risk premium.

What determines the term of the loan? In Merton's framework arbitrage determines a relationship between the length of the loan, leverage and volatility, but the actual length of the loan is indeterminate. In discussing the wool industry, the term of the loan was treated as given by industry practice. It is only with the introduction of asymmetric information and the conflict of interest between debt and equity that the indeterminacy is resolved. Put simply, a lender is unwilling to extend the term of the loan indefinitely because of the fear that the equity holders will have time to devalue the collateral by excess production. The conflict of interest between lender and borrower is the obstacle to long term financing of commodity schemes. Experience with the wool industry bears out this insight. As mentioned above, the wool industry is restructuring its debt towards longer term sources of finance. It has only been able to do so, however, since the government guarantee has been in place.

To conclude, stock acquisition in a commodity stabilisation scheme such as the Australian wool marketing system can be financed in part by borrowing, reducing the financial input required by industry or the government. There is, however, a conflict of interest between debt and equity which means that finance is only available on short terms. As stocks build up the risk premium rises rapidly and beyond a certain point the cost of stock holding increases very rapidly. The scheme is then subject to speculative attack and eventual failure as in the models of Townsend (1977) and Salant(1983).

If government intervenes and underwrites the borrowing, then the risk is transferred to the public sector, leading to an acute conflict between the industry and the public interest. This outcome is well illustrated by the current crisis in the Australian wool marketing arrangements.

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