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STABILISATION AND RISK REDUCTION IN AUSTRALIAN AGRICULTURE*

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Agricultural producers typically are faced with risk about the yields they will experience and the prices they will receive. Stabilisation schemes can spread risk and thereby reduce the risk faced by individual producers. The risk-reducing capacity of a scheme and the cost of risk reduction depend upon the design of the scheme. In particular, it is important to distinguish between risk and instability. A classification of scheme designs is presented to bring out the effects of various design types. Schemes for the wheat industry are given most attention.

Introduction

Although there is an extensive theoretical literature on price stabilisation policies, relatively little attention has been given to schemes operated by a single country in an attempt to reduce risk faced by exporters. Instead, attention has been focused on schemes intended to stabilise world prices (or prices within a closed economy) by means of buffer stock or buffer fund arrangements (Massell 1969). Recent summaries of this literature have been made by Anderson, Hazell and Scandizzo (1977), Just (1977), Colman (1978) and Turnovsky (1978). For nearly all commodities, Australian exports are too small to affect the world price significantly, so unilateral implementation of a buffer stock to stabilise world prices is impractical.

The aspects of stabilisation examined in this paper are related to the theory of economic behaviour under uncertainty, and stabilisation is viewed as a form of government intervention to spread, and thus to transfer, risk. There is now a large body of literature on the conditions for such a transfer to be advantageous. Lloyd (1977) has reviewed developments and controversies in the context of Australian stabilisation policy but stabilisation policy in general is beyond the scope of the present paper.

Although agreement is by no means unanimous, the case for transferring risk to the government through stabilisation has been held (see, e.g. Arrow and Lind 1970 and Samuelson 1964) to depend on whether:

(a) the risks are independent of national income as a whole;
(b) the private capital market is incapable of optimally spreading risks, so that individual producers (or consumers) must bear substantial risks; or
(c) stabilisation offers a mechanism which enables the government to bear risks at costs lower than those either of leaving individual producers to bear risks or of shifting risks to the private capital market.

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The independence condition will frequently be met by crops with risky yields. Whether it holds for risky prices depends on the relationship between the world and domestic economies (e.g. on whether commodity prices vary procyclically).

It is virtually impossible to address point (b) simply by scrutinising the structure of the private capital market for imperfections. Rather, it is necessary to examine the behaviour of individual producers for indications that they are subject to risks which they have been unable to transfer. If risk-averse producers are forced to bear substantial risks they will display a significant response to changes in risk levels. Empirical evidence of such risk-responsive behaviour has been found in several studies, such as those reviewed and conducted by Just (1974, 1975, 1977).

The major focus of this paper is on point (c). In order to assess the costs and benefits of stabilisation it is necessary to examine the principles on which stabilisation schemes are designed. In particular, it is important to determine whether stabilisation should involve elimination of all variability or merely the smoothing out of unforeseen fluctuations. Many of the costs that have been attributed to stabilisation in general probably apply only to particular designs. A classification of scheme designs is presented to illustrate this point.

This classification will employ the crucial distinction between risk[1] and instability. It is necessary to distinguish between decisions that must be made without knowing what realisation a random variable will take and those that are made with this knowledge. People making decisions of the first type are subject to both risk and instability, while those making decisions of the second type are subject to instability only.

Even if stabilisation is shown to be preferable to non-intervention it is possible that other policies will achieve risk-reduction goals at lower costs. For instance, the government may assist in the provision of market insurance or hedging facilities. Some of these policies will complement stabilisation but others, such as the encouragement of futures markets, will be incompatible with it. When the costs of stabilisation are assessed it is appropriate to take account of the costs potentially imposed through disincentives for the formation of alternative institutions.

The discussion above has related to stabilisation purely as an instrument for risk reduction. Price policies have been used for a number of other goals. First, stabilisation in Australia has frequently been a euphemism for price support. Second, price stability may be considered desirable *per se* or on macroeconomic grounds. Third, price policies have been advocated as a method of stabilising rural incomes.

The first and second of these goals will not be considered here but the relationship between stabilisation for risk reduction and income stabilisation is worthy of comment. Schemes which reduce the riskiness of producers' revenue clearly tend to reduce the variability of income. However, the term 'income stabilisation' is frequently reserved for instruments which enable individuals to manage a variable flow of

[1] We follow the modern practice of using the terms 'risk' and 'uncertainty' as technical synonyms for subjective probability distributions.

income. Such instruments, which include income equalisation deposits (IEDs) and variable amortisation schemes, are not discussed here.

In summary, 'stabilisation for risk reduction' will be held to refer to reductions in the riskiness of a probability distribution of income, and 'income stabilisation' to methods of dealing with an unstable but known income. This paper will deal only with the former.

Considerations in Design of Schemes

Assumptions and terminology

The stabilising country is assumed to have a share of the world trade sufficiently small that changes in its exports have no effect on the world price, which is regarded as exogenous. The world price in period t, $P_w(t)$, is assumed to vary about a long-run expected value (or trend). It may follow a cyclical path and may be affected by random shocks.

People form 'expectations' of $P_w(t+1)$, $P_w(t+2)$, . . . on the basis of the information available to them at period t. The expectation of $P_w(t+i)$ held at time t is denoted by $P_w{}^*(t, t+i)$ and is assumed to be the same for producers, consumers and government. Arguments for stabilisation based on the suggestion that government is better informed than producers are thus ignored. In general, people will be better informed about likely prices in the near future than in more distant periods. Thus the subjective distribution of $P_w(t)$ held at period t-i will tend to decrease in spread, and its mean, $P_w{}^*(t\text{-}i, t)$, will tend to converge to the value of $P_w(t)$ actually realised as i (the number of periods in advance for which 'expectations' are formed) becomes smaller. This process is illustrated in Figure 1.

The price paid by domestic consumers is denoted by $P_d(t)$ and that received by producers by $P_r(t)$. Both of these prices are assumed to be set by a statutory authority. Prices are expressed net of transport and marketing costs so that, in a free market, $P_d(t) = P_w(t) = P_r(t)$.

The generally announced motivation for stabilisation schemes, even when they involve price support, is the reduction of risk for producers (and sometimes consumers). These people are assumed here to be averse to risk.

Producers are assumed to be faced with three types of risk[2]:

(a) risk about the price they will receive;

(b) risk about factors affecting the relationship between planned total output and actual total output, e.g. droughts, epidemics; and

(c) risk about factors affecting their own output only, e.g. local weather, personal mismanagement.

In making the decision as to what to spend on inputs, a producer who took no account of risk would presumably attempt to maximise

[2] Producers will also be concerned about the interaction between risk about returns from the commodity in question and risk about other sources of income (including other products). Using Appendix proposition A.5 it can be shown that, if these risks are independent or positively correlated, risk about returns from one product will increase the riskiness of total income and thus the qualitative propositions contained in the paper will carry over to a multi-commodity world. Their quantitative importance will, of course, vary with the importance of the commodity as a source of income.

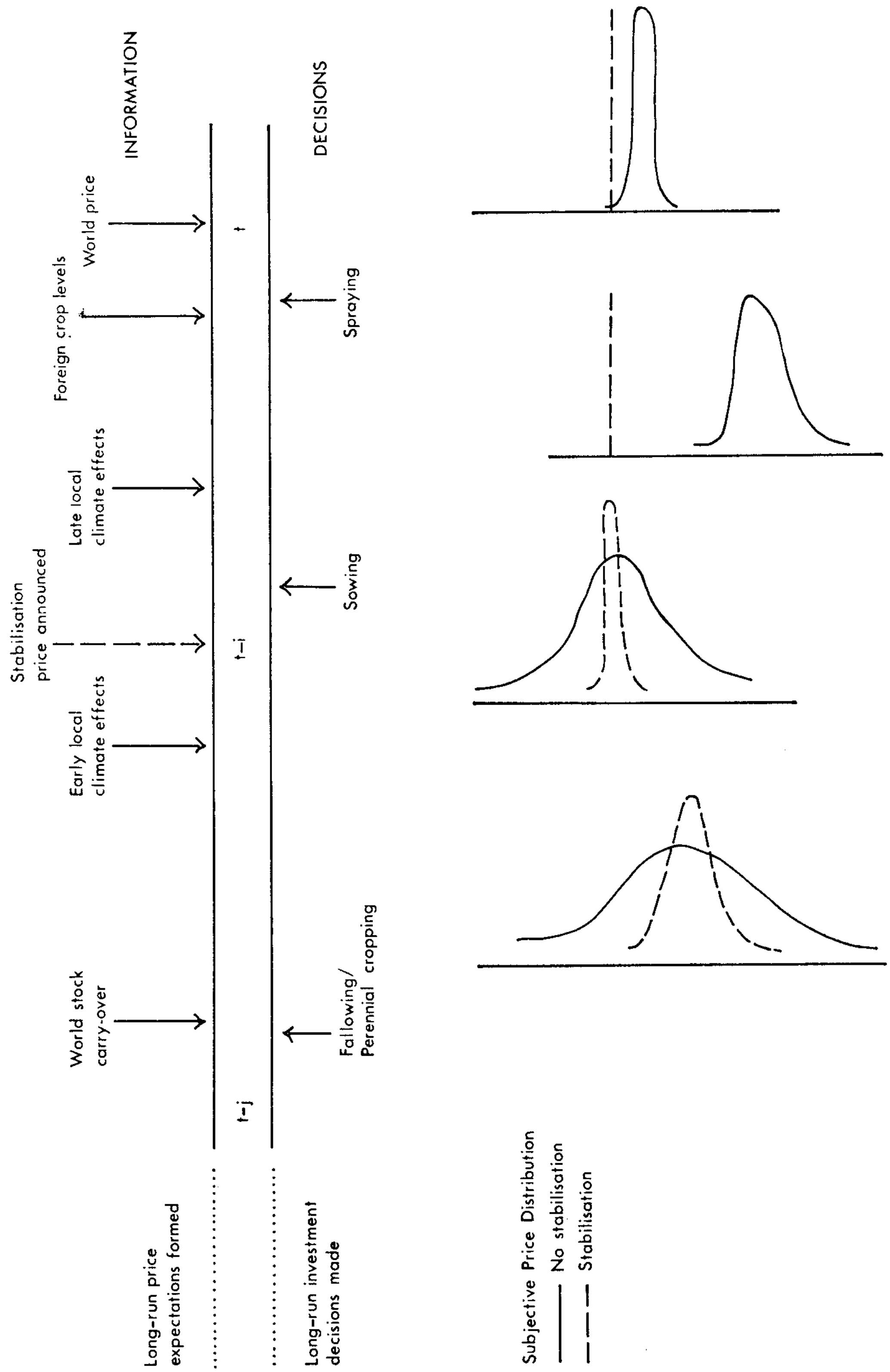

FIGURE 1—Formation of price 'expectations' under free and stabilised markets.

expected profits. However, a risk-averse producer, with concern over losses in times of misfortune, presumably would seek to maximise expected utility, where utility would be a concave function of profits.

The input decisions of the ith producer are assumed to depend on:

(a) the probability distribution of $P_r(t)$; and

(b) the probability distribution of output. This may be summarised as a function $F_i(x,U,u_i)$, where x is a vector of inputs, U a vector of random factors such as climate, with element u_i affecting the output of producer i only.

The output $Q_i(t)$ of the ith producer depends on:

(a) the producer's input decisions; and

(b) realisation of U and u_i.

Consumption is based solely on the distribution of $P_d(t)$. In many cases, such as in the purchase of food (other than for further processing), domestic consumers can be assumed to consider only current price levels. Such consumers are subject to instability but not risk.

A classification of schemes

Most stabilisation schemes in the past have operated purely in response to price fluctuations and have not distinguished between predictable and unpredictable fluctuations, that is, between instability and risk. In order to examine the effects of changing one or both of these features, we present a simple classification of scheme designs.

(a) A scheme which returns to producers (as a group) in each period the revenue which they would have received on the world market if prices had been at their long-run (trend) expected values and aggregate output at its expected level (for given inputs and hence for given 'planned' output), i.e.

(1) $P_r(t)\ Q(t) = E[P_w]E[Q]$.

In a free market, producers can take advantage of high (expected) world prices by increasing output. Thus it is likely that P_w and Q are positively correlated and that $E[P_w]E[Q]$ will be less than $E[P_wQ]$. Oi (1961) has pointed out the losses to producers that are associated with the elimination of predictable price variations.

(b) A scheme which returns to producers (as a group) the revenue which they would have received on the world market if prices had been at the values expected at some previous period and aggregate output at the expected value (given that price estimate), i.e.

(2) $P_r(t)\ Q(t) = P_w{}^*(t\text{-}i,t)\ E[Q(t) \mid P_w{}^*(t\text{-}i,t)]$.

Under both design types 1 and 2, producers will alter their input decisions and hence their expected levels of output, since revenue per unit of input has been fixed in advance. It may thus be difficult to solve the equations analytically and to set $P_r(t)$. A more fruitful approach is to estimate $E[Q(t)]$ directly after input decisions have been made. This is taken up further below.

(c) A scheme which pays producers for their actual output at the long-run expected value of world price, i.e.

(3) $P_r(t) = E[P_w]$.

(d) A scheme which pays producers for their actual output at the price expected in some previous period, i.e.

(4) $P_r(t) = P_w{}^*(t\text{-}i,t)$.

An authority must also set consumer prices, and three particular schemes are considered here (where domestic consumption is $C(t)$):

(a) Charging consumers the ruling world price, scheme A, where $P_d(t) = P_w(t)$.

(b) Charging consumers the price paid to producers (plus handling costs etc.), scheme B, where $P_d(t) = P_r(t)$.

(c) Charging consumers a price which enables the authority to break even each year, scheme C, where $P_d(t)C(t) + P_w(t)\ (Q(t) - C(t)) = P_r(t)Q(t)$.

A scheme will be specified as, for instance, A2, if its consumer price is specified as in scheme type A and its producer price as in equation (2). The major features of these schemes are summarised in Table 1.

TABLE 1

A Summary of Features of the Classification of Stabilisation Schemes

Scheme	Takes yield fluctuations into account	Stabilised for predictable fluctuations	Reduction of producer risks[a]	Effect on domestic consumer risks[a,b]	Effects on output[a]
A1	Yes	Yes	— —	Nil	?[c]
A2	Yes	No	— —	Nil	+
A3	No	Yes	—	Nil	?
A4	No	No	—	Nil	++
B1	Yes	Yes	— —	?	?
B2	Yes	No	— —	?	+
B3	No	Yes	—	—	?
B4	No	No	—	—	++
C1	Yes	Yes	— —	+	?
C2	Yes	No	— —	+	+
C3	No	Yes	—	+	?
C4	No	No	—	+	++

[a] The more +(—) signs the greater the increase (reduction) in risk.

[b] If consumers are fully informed of prices when they make an economic decision, a reduction in instability will lead to a loss of consumer welfare as pointed out by Waugh (1944). The results in this column apply only to consumers faced with risk and instability.

[c] Schemes which eliminate predictable upward fluctuations in price may thereby reduce output in some years.

In order to implement any of these designs, a number of practical decisions must be made. These decisions are now reviewed.

Estimation of $P_w{}^*(t\text{-}i,t)$ *and* $E[P_w(t)]$. If the scheme is intended to stabilise, rather than support, prices, it is necessary to obtain an unbiased estimator of the long-run expected value $E[P_w(t)]$. If the object of the scheme is risk reduction, then an estimator of $P_w(t)$ should be efficient and available as far in advance as possible. These two objectives tend to be in conflict. The effects of errors in forecasting are discussed below.

In each period t-j, producers make decisions affecting output in period t on the basis of their subjective distributions of $P_r(t)$ and of yields. If the stabilisation scheme employs an estimate $P_w{}^*(t\text{-}i,t)$ of $P_w(t)$, then the subjective distribution of $P_r(t)$ held in period t-j is significantly affected by the choice of t-i, the time at which the estimate is made.

$P_w{}^*(t\text{-}i,t)$ is affected only by information which becomes available by period t-i. Since information about world markets received after this time affects expectations of $P_w(t)$ and not of $P_r(t)$, in general if $j<i$, $P_w{}^*(t\text{-}j,t) \neq P_r{}^*(t\text{-}j,t)$. This divergence is a source of resource misallocation in economic decisions made after period t-i.

On the other hand, the riskiness of the subjective distribution of $P_r(t)$ is reduced by the fact that it is unaffected by shocks to the world market after period t-i. In particular, for $j \geqslant i$, $P_r{}^*(t\text{-}j,t) = P_w{}^*(t\text{-}j,t)$ but the subjective distribution of returns is less risky under stabilisation. Hence, the economic decisions of risk-averse producers will be closer to those which would be made in a risk-free situation.

In the case of cropping, the major decision is what and how much to sow. (The time at which sowing takes place is, of course, also a decision variable and will differ both between farms and over time on any one farm.) Because of this, the schemes described above may be implemented by announcing prices as late as possible but before significant numbers of farmers have made their sowing decisions.

The earlier $P_w{}^*(t\text{-}i,t)$ is announced, the less information specifically affecting period t will be used and the more $P_w{}^*(t\text{-}i,t)$ will resemble an estimate of the trend value $E[P_w(t)]$. Hence, an earlier announcement shifts a scheme of design type 2 towards design type 1.

Estimation of expected output. It has been assumed thus far that, given the distribution of $P_r(t)$, $E[Q_t]$ could be estimated when $P_w{}^*(t\text{-}i,t)$ was announced, so that the total level of revenue could be announced at the same time. This requires the authority to have an accurate model of supply response to changes in both the expected value and shape of the probability distribution of prices.

In the case of crops, it might be easier to obtain a good estimate of unit yield. The authority could then estimate the area sown and attempt to stabilise unit returns. A more precise procedure, taking account of the fact that average productivity of land tends to vary inversely with area sown, would be to estimate expected output as a function of area and stabilise returns appropriately for the area sown. For simplicity, it is assumed here that yields do not vary with area sown.

Regional basis. The risk-reducing properties of a scheme would clearly be enhanced if the scheme could compensate for uncertain factors affecting output in a particular area but not greatly affecting total national output. A limit on the number of regions into which the country could be divided would be set by administrative costs and the possibility of fraud.

Payment procedures. In designing a scheme to compensate for fluctuations in aggregate yield, care must be taken to avoid creating incentives for producers to reduce their own levels of output. Two methods of avoiding this problem of 'moral hazard' are considered here. In the first, producers receive a unit price which depends not on their own but on aggregate yield. In the second, producers insure against the event of a fluctuation in aggregate regional revenue.

More formally, the following payment procedures (for schemes of design type 2) are considered.

(a) In payment procedure I, which is appropriate to a compulsory national scheme, the authority announces $P_w{}^*(t\text{-}i,t)$ and fixes a unit return. The sown area is estimated during the season and producers' total revenue fixed as $P_r(t)Q(t)$ = (expected return/unit area) $\times$ total area sown.

(b) In payment procedure II, which is appropriate to a voluntary regional scheme, the authority announces an expected unit return and, hence, an expected aggregate regional revenue as in payment procedure I. Producers are then offered the opportunity to insure against fluctuations in aggregate regional revenue. Each producer can select a proportion of the aggregate revenue (roughly equivalent to the returns from some given proportion of the land in the region) to insure. Producers who insure K, $0 < K \leqslant 1$, receive, in addition to the world price for their actual output, an insurance payment equal to $K\{$(expected return/unit area) $\times$ area sown $- P_w(t)Q(t)\}$, which may be positive or negative. This payment procedure is assumed to operate in the farm income stabilisation plan discussed below. The IAC (1978, Appendix 7.4) discussed this proposal in some detail.

The choice of payment procedure is a major factor in determining the level of administrative costs. If a statutory marketing authority exists prior to the implementation of stabilisation, the decision to undertake stabilisation using payment procedure I will not involve significant additional costs. What is required is the (considerable) information necessary to calculate the stabilisation price.

On the other hand, payment procedure II is likely to involve significant additional costs. It will be necessary to maintain accounts with each person 'insured' and to collect money in periods of high prices as well as to make payments in periods of low prices.

Partial implementation. Financial constraints may prevent the schemes discussed above from being implemented in full. Stabilisation costs may be reduced either by setting a band around the stabilisation price, P_r, and acting to keep producer prices within this band, or by making up only a part of the difference between P_r and P_w.

Operation costs are likely to be approximately linearly related to the volumes of funds used, while the benefits of committing funds to stabilisation are likely to be greater in the case of extreme fluctuations. Accordingly, the setting of a stabilisation band is perhaps the better method of partially implementing the schemes discussed above.

Robustness. Errors in forecasts may involve significant extra costs for schemes. In types 1 and 3, the danger is that the stabilisation price will be based on an estimate which differs from the true long-run value $E[P_w]$. Errors of this type will be difficult to detect and amend.

In types 2 and 4, distortions will arise if the price forecaster uses a worse estimate than that employed by well-informed producers. These distortions will be more severe if the estimate is considerably biased. However, because a new estimate is derived each year, it should be easier to correct such errors.

Table 1 above contains a brief summary of the features of schemes of different design. Some of these points are discussed in the following section.

Risk Reduction and Scheme Design

Risk and allocative decisions

Producers. A theory of the firm under uncertainty has been developed recently by authors such as Baron (1970), Sandmo (1971), Leland (1972) and Coes (1977) and applied to issues in commodity stabilisation in agriculture by other authors such as Blandford and Currie (1975). Such writers have examined the idealised situation in which production decisions for period t are made in a single period, say $t\text{-}i$, on the basis of the subjective price distribution held at that time. In the Appendix, some further results along these lines are developed.

Typically, but not always, risk-averse producers will employ fewer inputs than would be optimal in the absence of either risk or risk aversion. (See the Appendix and Pope and Just 1977.) If all risky variables were stabilised at their means, the choice of inputs would be the same for risk-neutral and risk-averse producers. Just (1978) has explored the welfare implications of producers' response to stabilisation of all risky variables.

The schemes considered here do not, however, stabilise all risky variables at their means. They reduce or eliminate the risk in some variables, such as prices and aggregate yields, which contribute to risk in returns. They may also shift the means of these variables. The distinction between risk and instability is useful here. Since compensation for predictable price fluctuations results in a reduction in instability rather than in risk, it involves a cost in resource misallocation because the expected producer return differs from the world price anticipated at the time production decisions are made. Oi (1961), in examining a situation of pure instability due to demand fluctuations, has shown that a competitive producer will lose from price stabilisation. This is because of the loss of opportunities to vary output as prices fluctuate.

The results presented in the Appendix are useful for examining the consequences of eliminating unpredictable fluctuations or risks. In the idealised situation where all production decisions are made at a single time, schemes of design types 3 and 4 both eliminate price risk but a scheme of type 3 also involves a shift in the mean of the subjective distribution of prices.

Similarly, types 1 and 2 achieve the same reduction in risk, but type 1 eliminates predictable fluctuations and thereby creates a divergence between expected world prices and producer returns.

This distinction is blurred when production decisions are made over a number of periods. Schemes of design types 1 and 3 provide greater reductions in risk for decisions made in periods prior to $t\text{-}1$. Furthermore, types 2 and 4 can lead to shifts in mean returns in some periods in which production decisions are made. For, even if $P_r{}^*(t\text{-}i,t) = P_w{}^*(t\text{-}i,t)$, the two expectations are likely to diverge in later periods.

However, producers will take no account of new information about world prices since it no longer affects producer prices under the stabilisation schemes. They will thus tend to misallocate resources (from a national viewpoint) when making decisions in periods after *t-i*.

The effect of moving from a scheme of design type 3 or 4 to one of type 1 or 2 depends on the relationship between individual and aggregate yield experience. If the individual's yield is positively correlated with aggregate yield, the variations in individual yield can be divided into two components. The first of these components is linearly and positively dependent on variations in aggregate yield, while the second is independent of these variations. Thus, if individual and aggregate yields are positively correlated, Appendix propositions A.5 and A.6 can be used to show that compensation for fluctuations in aggregate yield will lead to a reduction in returns risk.

From proposition A.6, it is apparent that eliminating price risks leads to a reduction in returns risk, where return is yield times price. A sufficient condition for this reduction in risk to induce an increase in optimal output is given by proposition A.4. This proposition can be applied to returns rather than to prices when yield uncertainty is 'multiplicative'.

Thus, designs such as 2 and 4, which achieve a pure reduction in risk, will normally lead to an increase in output, though output will still be less than when risk is eliminated (or producers are risk-neutral). Since design 2 normally achieves a greater reduction in risk than design 4, output will be closer to the risk-neutral level under this design. Since designs 1 and 3 change both the mean and the riskiness of the subjective returns distribution, their effect on output is uncertain. However, on average, output will be higher than in the absence of stabilisation.

Stabilisation indeed has resource-allocative effects because it alters the distribution of returns arising from any input decision. Advocates of stabilisation have tended to stress the gains resulting from a less risky distribution of returns, while opponents have emphasised efficiency losses arising from differences in the expected values of these distributions.

Consumers. The effects of stabilisation on consumers depend on whether consumers are subject to risk or only to instability, i.e. on whether they make economic decisions before or after prices are revealed. In general, processors of primary products are likely to face risk in their input prices but final consumers are likely to face instability only. It is therefore important to decide at what point in the processing chain stabilisation should be applied.

Schemes of design C transfer instability to domestic consumers rather than to government. The losses resulting from such an increase in price instability have been identified by Samuelson (1972). If domestic consumers are faced with risk as well as instability, such a scheme is likely to spread risk much less efficiently than one which transfers risk to taxpayers, since consumers are likely to be relatively concentrated.

A scheme of design B will have benefits for consumers if they are faced with risk as well as instability. If they are faced with pure instability, they will suffer losses from stabilisation analogous to those encountered by producers under analogous conditions. These losses, first pointed out by Waugh (1944), arise because consumers are unable to vary their demand in response to price changes. Unless consumers are faced with significant risk, a scheme of design A is likely to be most appropriate.

Voluntary and compulsory schemes

Stabilisation schemes for risk reduction amount to compulsory insurance. If a voluntary market arrangement could achieve the same ends at similar costs, it would normally be preferred. One frequently advanced alternative to stabilisation has been the use of futures markets. In this section, some features of voluntary and compulsory schemes are compared and some suggestions are given as to why farmers have made relatively little use of futures markets.

Futures markets offer farmers a riskless possibility of complete hedging only if they know with certainty what their output will be. If they sell futures contracts which exceed their output, they will subject themselves to risks which may be quite significant. If, in addition, they are worse informed than other investors (as is quite possible), they will tend to lose money on hedges which are not covered by their own production.

A voluntary 'insurance' scheme should thus cover both price and yield risk. The Report on Rural Income Fluctuations (IAC 1978) suggests a Farm Income Stabilisation Plan (FISP) along these lines. The proposed plan involves a regional base for yield insurance, thereby avoiding the moral hazard problems which arise with crop insurance for individuals. It is essentially equivalent to a scheme of design type A1 in which payment procedure II is adopted.

Because design type 1 involves compensation for predictable fluctuations, it seems likely that the proposal would face 'adverse selection' problems, i.e. farmers would not insure if the world price were expected to be above the long-run average. It would thus appear to be necessary to modify the scheme towards design type 2, so that only unpredictable fluctuations would be insured against.

The major advantage of a voluntary scheme would be that producers who were risk-neutral or whose yield experience differed significantly from the regional average could choose not to participate. The degree of correlation between individual farm yields and regional yields will tend to vary inversely with the size of the region. The major disadvantage would be that problems with forecast errors would be much more serious. A bad forecast would leave the scheme open to arbitrage by well-informed speculators.

It is also important to note that any insurance scheme, voluntary or otherwise, will deal with highly correlated losses and gains, whereas most insurance arrangements pool uncorrelated risks. Highly correlated risks can be spread only by a large organisation with a diversified portfolio. In some cases only the government will be able to establish such insurance. It is unlikely that it will arise spontaneously from a competitive market.

Wheat Industry Stabilisation

Since 1948 there has been a series of five-year Wheat Industry Stabilisation Schemes (WISSs). The schemes have been similar in their basic characteristics, except for the period 1969-72 in which attempts were made to limit production through the imposition of quotas. They involved the setting of a home consumption price and a stabilised producer price. The producer price was set without close regard either to fluctuations in yield or to predictable short-run variations in world prices. The producer price scheme may thus be characterised as being of design type 3. The setting of the consumer price typically has been a compromise between a desire to maintain stable prices and a desire to minimise payments into and out of the stabilisation fund. As a result, the scheme shares characteristics of both design types B and C. Thus, consumers subject to instability but not risk would normally lose from the implementation of the scheme. Intermediate consumers, such as flour millers, who may have been subject to risk, could gain from the scheme.

The WISSs suffered from problems associated with stabilising for predictable price variations, such as failure to adjust output to changes in world prices. Longworth (1967) estimated that growers lost in excess of $400m because of the operations of the WISS between 1948/49 and 1953/54 when world prices were well above stabilised producer prices. He suggested that much of this was an overall loss to society rather than a pure transfer to consumers.

The WISSs to date have also failed in the implicit objective of stabilising producer incomes. Houck (1973) and BAE (1977) found that 90 per cent of the variability in wheat industry aggregate revenue arose from fluctuations in quantity and concluded that price stabilisation was not a cost-effective method of stabilising incomes. It should be noted, however, that the operation of the WISSs and the International Grain Agreement significantly reduced price variability.

The scheme for the next five years has recently been announced. The minimum producer realised price will be 95 per cent of a three-year moving average of past, present and forecast future prices. The forecast will be announced just before harvest. Prices for human consumption will respond to world prices with a one-year lag. However, the consumer scheme explicitly incorporates an element of monopoly pricing for the first time and therefore is not a pure stabilisation scheme.

Under the new formula, expected producer returns and anticipated world prices at the time of sowing are more closely linked than previously. However, to achieve the risk-reduction objective it would be preferable to use a forecast price which was announced before crops were sown. This would shift the scheme further towards design type 4. Of course, there would still be no compensation for aggregate yield fluctuations, which are a major source of risk.

Conclusion

The risk-reduction capabilities of stabilisation schemes depend significantly on scheme design. Our classification of schemes is intended to bring out the distinction between risk and instability and thus to sharpen and facilitate consideration of design and evaluation of schemes. An important conclusion from this analysis is that traditional pure price stabilisation schemes are unlikely to be optimal vehicles for risk reduction.

A great deal of work needs to be done before a detailed assessment of the costs and benefits of stabilisation is possible. First, it is necessary to consider possible methods of partial stabilisation, such as price-band schemes. It is not likely that complete elimination of price or yield risk will often be a cost-effective procedure. Second, it is necessary to examine in more depth the complex interaction between stabilisation and other methods of risk reduction, both public and private.

APPENDIX

The Firm under Uncertainty

Risk aversion and risk neutrality

A common approach to the analysis of risk-averse behaviour under uncertainty has been the use of comparisons with risk neutrality or, equivalently, with the certainty case where random variables are fixed at their means. The results presented in this section are based on those of Sandmo (1971) and Pope and Just (1977).

In the terminology of the paper, producers choose an input vector, x, to maximise expected utility of profits

(A.1) $$E[U(\pi)] = E[U(P_r(t)F(x,U,u_i) - w'x)]$$

where w_j is the wage rate for factor j.

The first-order conditions for an optimum are of the form

(A.2) $$E[U'(\pi)(P_r(t)F_j\text{-}w_j)] = 0,$$

where $F_j = \partial F/\partial x_j$.

This may be restated as

(A.3) $$E[U'(\pi)]E[P_r(t)F_j - w_j] + \text{cov}[U'(\pi), P_r(t)F_j] = 0.$$

The sign of the covariance term is crucial. If it is negative, then $E[P_r(t)F_i] > w_i$. If the production function has the property that $F_{ij} \geqslant 0$, $i \neq j$, then this implies that a risk-averse producer will use less of all factors than will a risk-neutral producer.

If P_r is independent of U and u_i and uncertainty is multiplicative, so that

(A.4) $$Q = F(x, U, u_i) = g(x)h(U,u_i),$$

then cov $[\pi, P_r(t)F_i]$ is positive and cov $[U'(\pi), P_r(t)F_i]$ is negative for risk-averse producers.

An alternative model of output uncertainty, illustrating the fact that risk-averse producers are likely to increase their use of factors whose returns are negatively correlated with profits, has been given by Pope and Just. They assume constant prices and

(A.5) $$F(x, U, u_i) = g(x) + h(x)u_i,$$

with $E[u_i] = 0$.

If $h(x) > 0$ and $\partial h/\partial x_i > 0$, cov$[U'(\pi), P_r(t)F_i]$ is positive and factor use will tend to be higher for a risk-averse than for a risk-neutral producer.

Comparative statics

Although the reactions of firms to changes in the distribution of prices are important in stabilisation theory, they have received relatively little attention in the literature until recently. Several results have been derived on the assumption that there is price uncertainty but not output uncertainty, and these will be discussed and extended here. In a situation of certain output, a cost function, $C(Q)$, can be derived and the first- and second-order conditions on output are, respectively,

(A.6) $E[U'(\pi)\ (P_r - C'(Q))] = 0,$

(A.7) $D = E[U''(\pi)\ (P_r - C'(Q))^2 - U'(\pi)C''(Q)] < 0.$

These conditions are used in proofs of the following propositions.

Proposition A.1: If the mean of the distribution of prices increases while all higher moments remain unchanged, then decreasing absolute risk aversion is a sufficient condition for an increase in optimal output.
Proof: Sandmo (1971), pp. 68-9).

Proposition A.2: Decreasing absolute risk aversion is a sufficient condition for a multiplicative reduction in price risk to lead to an increase in optimal output.
Proof: Coes (1977).

These propositions describe special cases of an upward shift in the distribution of prices and a decrease in the riskiness of prices, respectively. Stronger conditions on utility functions are required for the more general cases. Proposition A.3 deals with an upward shift which need not be uniform.

Proposition A.3: Let g be a function s.t. $g(y) \geqslant y$ for all y. Then sufficient conditions for output to increase as the distribution of prices changes from that of P_o to that of $g(P_o)$ are:

(a) that relative risk aversion is less than 1, and
(b) that decreasing returns to scale prevail so that $C'(Q)Q > C(Q)$ for all Q.

Proof: Let $P_r = (1\text{-}k)P_o + kg(P_o)$. Differentiating (A.7) with respect to k:

(A.8) $E[U''(\pi)((P_r - C'(Q))^2\partial Q/\partial k + (P_r - C'(Q))Q\partial P_r/\partial k) + U'(\pi)(\partial P_r/\partial k - C(Q)\partial Q/\partial k)] = 0,$

so that

(A.9) $\partial Q/\partial k = (-1/D)E[(\partial P_r/\partial k)(U''(\pi)(P_r - C'(Q))Q + U'(\pi))].$

From condition (b), $C'(Q) - Q > C(Q)$ and hence $(P_r - C'(Q))Q < \pi$. Combining this with condition (a), it follows that

(A.10) $- U''(\pi)(P_r - C'(Q))Q/U'(\pi) < 1,$

or equivalently that

(A.11) $U'(\pi) + U''(\pi)(P_r - C'(Q)) > 0.$

Therefore, since $\partial P_r/\partial k > 0$, the RHS of (A.9) is positive and $\partial Q/\partial k > 0$. Thus output increases continually as k shifts from zero to one, and the distribution of P_o shifts upwards (in a nonuniform way) to $g(P_o)$.

Proposition A.4: If the distribution of P second-stochastically dominates[3] that of P_o, then the following are sufficient conditions for optimal output to be higher under P than under P_o:

(a) $r_r(\pi)$ is increasing and less than 1,

[3] See Hadar and Russell (1969) and Anderson, Dillon and Hardaker (1977) for elaboration of stochastic dominance.

(b) $r_a(\pi)$ is decreasing, and
(c) decreasing returns to scale prevail so that $(P_r - C'(Q))Q < \pi$.

Proof: It is sufficient to show that $\partial E[U(\pi)]/\partial Q$ is concave in P_r under the stated conditions. If P second stochastically dominates P_o and g is a concave function, $E[g(P)] > E[g(P_o)]$. Thus, for each Q, $\partial E[U(\pi)]/\partial Q$ will be higher for P than for P_o and the optimal G will be larger for P than P_o when U is concave. Now, from condition (c) and because condition (b) implies $U''' > 0$,

$$\begin{aligned}(\text{A.12}) \quad \partial^2 E[U(\pi)]/\partial Q \partial P_r &= E[2U''(\pi)Q + U'''(\pi)(P_r - C'(Q))Q^2] \\ &= QE[2U''(\pi) + U'''(\pi)(P_r - C'(Q))Q] \\ &\leqslant QE[2U''(\pi) + U'''(\pi)\pi].\end{aligned}$$

$r_r'(\pi)$ has the same sign as $-(U'''(\pi) + (1+r_r(\pi))U''(\pi))$

and hence, if $r_r(\pi)>0$ and $r_r(\pi)<1$,

$$(\text{A.13}) \quad E[2U'''(\pi) + \pi U''(\pi)]<0$$

and $\partial E[U(\pi)]/\partial Q$ is concave in P_r.

The random return and revenue variables which have been discussed in this paper are generally formed by adding or multiplying two or more random variables, such as prices and yields for different crops. According to propositions A.5 and A.6, reductions in the riskiness of these contributing variables lead to reductions in the riskiness of the return variables under suitable independence conditions.

Proposition A.5: Let X and Y be random variables with $E[X] = E[Y]$. Then the following conditions are equivalent:

(a) X is riskier than Y, and
(b) $X = Y + Z$ where Z is independent of X and $E[Z] = 0$.

Proof: Rothschild and Stiglitz (1970).

Proposition A.6: Let X and Y be positive random variables such that $E[X] = E[Y]$ and X is riskier than Y. Let W be a positive random variable independent of both X and Y. Then WX is riskier than WY.

Proof: Let $Z = X - Y$ and $V = WZ$. Note that Z is independent of W and $E[Z] = 0$. It is sufficient now to show that V is independent of WX.

For any w, x

$$\begin{aligned}(\text{A.14}) \quad E[V|W = w, X = x] &= wE[Z|W = w, X = x] \\ &= wE[Z] = 0.\end{aligned}$$

Now, for any k, $E[V|WX = k]$ is the evaluation of an integral with zero values everywhere and is thus zero. Hence

$$E[V|WX = k] = 0 = E[V]$$

and thus V is independent of WX.

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