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A NOTE ON THE VIABILITY OF RAINFALL INSURANCE – REPLY

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John Quiggin's note on the viability of rainfall insurance (Quiggin 1986) raises some important points relevant both to the crop insurance model published by Bardsley, Abey and Davenport (1984) and to its implications for rainfall insurance in Australia. It should be noted that the whole of this discussion relates to the viability of unsubsidised insurance in the absence of any government drought assistance. It is not related to the issue of using subsidised insurance as a vehicle for delivering government drought assistance, an issue which is currently receiving attention through the Industries Assistance Commission inquiry into crop and rainfall insurance. Quiggin's remarks may be summarised as follows.

(a) The government is able to act as a risk neutral, or almost risk neutral, insurer, provided that the amount of insurance sold is small and that the government has other statistically independent assets in its portfolio.
(b) Bardsley et al. provide misleading and unrealistically high estimates of the impact of administrative costs, which lead them to conclude that insurance is unlikely to be viable.
(c) Bardsley et al. assume that administrative costs are independent of the amount of insurance sold. In fact, it can be plausibly argued that they are proportional to the amount of insurance sold.

The first of these points is quite important, and it will be discussed in detail below.

The second can be dealt with quickly. The parameter r, which is the cost of liquidity, is estimated by Quiggin at 10 per cent. He appears to have interpreted r as an interest rate. In fact, this parameter measures not the cost of holding funds but the cost of holding them in a liquid rather than a fixed form. Bardsley et al. (1984) suggest that the interest rate spread between long and short lending may be an appropriate measure. Quiggin's estimate is far too high, perhaps by a factor of 10. The result is that his estimate of administrative costs and his second table are in error.

Quiggin claims that the parameter γ is a misleading indication of administrative costs and that these costs as a proportion of premiums will be substantially greater than γ. In fact, the opposite is true, and γ is quite a conservative indicator of administrative costs. This can be seen from Quiggin's own numerical example once the parameter r is set to a more appropriate value. If r is reduced from 10 per cent to 1 per cent, then in his example, with γ set at 10 per cent, administrative costs fall from 27.5 per cent of premiums to 2.7 per cent of premiums, which is well below 10 per cent.

The third point is quite reasonable and can, in fact, be used to simplify the insurance model. The modified model gives very similar results but is easier to use. This will be convenient when discussing Quiggin's first point.

A Modified Insurance Model

The notation will be the same as in Bardsley et al. (1984) and Quiggin (1986). The principal parameters and variables are as follows:

- δ is the correlation between the insured hazard and the insured person's income stream;
- τ is the spatial correlation of the risk;
- r is the liquidity premium on assets held for insurance purposes;
- t is a measure of residual risk (see below);
- ϕ is the coefficient of variation of the farmer's income stream;
- π is the administrative cost as a proportion of the actuarial premium;
- γ is the administrative cost as a proportion of the cost of self-insurance;
- β is the frequency with which the insurance pool turns over (that is, the actuarial premium is $1/\beta$);
- θ is the proportion of the risk insured; and
- p is the price of insurance.

When it is necessary for clarity, parameters relating to the farmer will bear the subscript 0, while those relating to the insurer will bear the subscript 1.

The parameter t is a measure of residual risk that the farmer or insurer is willing to bear, which is used in this model as an indicator of risk aversion. For the farmer the risk is of insolvency; for the insurer the risk is of exhausting the insurance pool. The parameter t is the ratio of the available liquid assets to the size of the risk (measured by the standard deviation of income). Roughly speaking, it is the number of times the average risk is covered by available liquid assets. Table 1 shows how t relates to the probability of insolvency under the assumption that the risk is normally distributed.

Following Quiggin's (1986) suggestion, assume that the administrative costs is proportional to the premium. Then:

$$(1) \quad \gamma = \pi\theta / r_0 t_0 \phi\beta$$

Equation (18) of Bardsley et al. (1984) is incorrect and should read:

$$(2) \quad p = \gamma/\theta + (r_1 t_1 / r_0 t_0)(\tau)^{0.5}$$

Substituting for γ gives:

$$(3) \quad p = \pi / r_0 t_0 \phi\beta + (r_1 t_1 / r_0 t_0)(\tau)^{0.5}$$

which is independent of θ. This may be used with equations (13) and (15) of Bardsley et al. to give a simpler model which does not require iterative solution.

As a simple application, note that demand for insurance is zero if $p > \delta$. A rule for the maximum level of administrative cost which an unsubsidised crop insurance market will sustain can then be derived. Insurance demand will be zero unless

$$(4) \quad \pi \leqslant [r_0 t_0 - r_1 t_1 (\tau)^{0.5}] \phi \beta$$

This is a useful rule of thumb, since all the parameters may be estimated quite easily. Some numerical estimates will be presented below.

The Risk Attitude of the Government

Return now to Quiggin's first point. Strictly speaking, it does not make sense to speak of the risk attitude to the government. The point at issue is whether the government should supply insurance like a risk neutral individual, or whether it should offer an insurance schedule which discourages risk taking.

Quiggin is quite correct to point out that the inclusion of independent risks in the government's portfolio will reduce the impact of the insured risk on the aggregate variability of that portfolio. However, it is not clear that the cost of risk bearing can be diversified away completely.

It is instructive to look again at Arrow and Lind's (1970) seminal paper on public risk bearing. They point out that the usual arguments on diversification may not apply where there is the possibility of moral hazard. This point has been developed in the literature on the principal–agent problem and organisational structure (Mirlees 1976; Shavell 1979; Singh 1985).

In a typical principal–agent problem, a risk neutral principal delegates decision making responsibility to an agent who has access to better information. Because of the way information is distributed, the principal cannot fully monitor the agent's actions but can observe the final outcome. The principal would like the agent to make decisions in a risk neutral manner but cannot distinguish appropriate risk taking from poor decision making. Thus the principal is led to punish risk taking by the agent. Given the informational constraints, this outcome is optimal (Mirlees 1976). Everybody is better off if the partnership acts as a risk averse decision maker. In a large organisation, this result can apply all the way down the line of command.

This result is especially relevant to crop insurance, less so to rainfall insurance. If the relevant information is widely dispersed, then decentralised decision making will be necessary. This will lead to both high administrative costs and risk averse behaviour, irrespective of the organisation's risk-pooling possibilities. A similar argument can be applied to multinational risk spreading and the cost of reinsurance on the world market (Borch 1962; Thompson 1985). Thus the conditions for risk neutrality of the insurer are stronger than those mentioned by Quiggin (1986). Not only must there be adequate risk-pooling opportunities but there must also be minimal scope for decentralised decision making.

These conditions are not theoretically impossible. They might be found with an idealised rainfall insurance system. Even so, there remains the principal–agent partnership between the (possibly risk neutral) government or reinsurer and the insurance agency.

Because of the principal–agent relationship discussed above and because the government does not have unlimited risk-pooling opportunities, complete risk neutrality of the insurer is unlikely. However, it is important to examine explicitly this risk neutral case.

Table 2 contains estimates for an insurance scheme for the Australian wheat industry of the maximum level of administrative costs (that is, the level which would reduce demand for insurance to zero) for a variety of risk attitudes. This table was calculated using equation (4). The following assumptions were made about parameters: $\delta = 0.65$, $\tau = 0.4$ (as in Bardsley et al. 1984), $r_0 = r_1 = 0.01$, $\beta = 7$, $\phi = 0.9$ (which is typical of the riskiest group of wheat growers in the Australian wheat industry, see BAE 1986). These parameters would be appropriate for a yield insurance scheme, as considered in Bardsley et al. (1984). They would be optimistic for a rainfall scheme, for which δ would be lower.

There is some evidence that wheat yields in Australia may be positively skewed (Battese and Francisco 1977). If this is so, then the t-values in Table 1 are too high, and the critical level of administrative costs in Table 2 is also too high. This would further reduce the likelihood of a viable insurance scheme. However, this effect is probably small.

Crop or rainfall insurance might be sold by a risk neutral insurer provided that administrative costs were reasonably low (see Table 2). However, the magnitude of potential benefits would be small (see Table 3). It is assumed in this table that administrative costs could be kept to 2 per cent of premiums (more extensive results are presented in BAE 1986).

TABLE 1

Risk Aversion Assumptions

Level of risk aversion	t	Probability of insolvency in next year[a]
		%
Nil	0	50
Low	1	16
Medium	2	2
High	3	0.1

[a] Assuming that the risk is normally distributed.

TABLE 2

Maximum Level of Administrative Costs: Cost is Shown as a Percentage of the Actuarial Premium

	Insurer's risk aversion		
Farmer's risk aversion	Nil ($t = 0$)	Low ($t = 1$)	Medium ($t = 2$)
Low ($t = 1$)	4.1	0.1	—
Medium ($t = 2$)	8.2	4.2	0.2
High ($t = 3$)	12.3	8.3	4.3

It can be seen that under these optimistic assumptions, if the insurer is risk neutral, then the farmers who are most exposed to risk might benefit to the extent of 15 per cent of their cost of risk bearing. A rough estimate of this cost of risk bearing is that it might be as high as 20 per cent of average cash costs for these farmers, but considerably less for the average farmer (BAE 1986). On this basis, the benefit from insurance would be at most 3 per cent of average cash costs. If the insurer is slightly risk averse ($t_1 = 1$), then the benefit to the group of farmers who are most exposed to risk would be less than 1 per cent of average cash costs. The benefit to the average farmer would in all cases be negligible.

This benefit, while small, might be worth having if such an insurance scheme were technically feasible. From the analysis above it is clear that administrative costs would need to be extremely small. This would rule out conventional multiple risk crop insurance, and some type of rainfall scheme which focused specifically on drought would probably be necessary. However, demand would be lower for rainfall insurance than for yield-based crop insurance unless it were very sophisticated (for example, through the use of remote sensing to assess drought conditions) and gave a payout which was closely related to yield reductions. This aspect is captured in the model above through the parameter δ. The estimates presented above are based on the assumption that the correlation δ is about 0.65, which is appropriate for a perfect yield insurance. If δ is lower than this, then the benefits quickly become negligible. Thus a simple rainfall lottery would be unlikely to provide any substantial benefit.

The feasibility of rainfall insurance remains a question of technology. In Canada, an experimental scheme is in operation which depends on reporting of daily rainfall by the farmer and the use of a crop growth model (BAE 1986). This does not seem to be a very satisfactory solution. Low administrative costs, of the order of 2 per cent, have been estimated, but the accuracy of this figure is not certain. However, many problems with the scheme have been reported. It is quite likely that reliable remote sensing or cheap tamper-proof automated weather stations could in the future make rainfall insurance technically feasible.

However, even then the results above suggest that unsubsidised rainfall insurance is not likely to make more than a small contribution to

TABLE 3

Net Benefit from Insurance for the Australian Wheat Industry: Benefit is Shown as a Percentage of the Farmer's Cost of Risk Bearing[a]

	Coefficient of variation of farmer's income				
Insurer's risk aversion	20%	40%	60%	80%	100%
Nil ($t = 0$)	0	5.8	10.7	13.6	15.5
Low ($t = 1$)	0	0	0.7	1.8	2.6

[a] Administrative cost is is 2 per cent of premium ($\pi = 0.2$). Farmer has medium risk aversion ($t = 2$).

alleviating the cost of output risk for the Australian wheat industry. This is of course a separate issue to that of using insurance as a vehicle for government assistance. Even though there is no significant market failure, in the sense that there is no important gap in the available risk markets, insurance might still be a useful measure for channelling assistance. Indeed, the Bureau of Agricultural Economics has recently argued that, assuming there is a social commitment to the provision of drought assistance (which may be justified on grounds of welfare and of free-rider problems in the private provision of assistance), subsidised regional rainfall insurance may be a useful measure for the implementation of government drought policy (BAE 1986).

References

Arrow, K. J. and Lind, R. C. (1970), 'Uncertainty and the evaluation of public investment decisions', *American Economic Review* 60(3), 364–78.

BAE (1986), *Crop and Rainfall Insurance*, A BAE Submission to the IAC, March 1986, AGPS, Canberra.

Bardsley, P., Abey, A. and Davenport, S. (1984), 'The economics of insuring crops against drought', *Australian Journal of Agricultural Economics* 28(1), 1–14.

Battese, G. E. and Francisco, E. M. (1977), 'Distributions of indemnities for crop insurance plans: with application to grain crops in New South Wales', *Australian Journal of Agricultural Economics* 21(2), 67–79.

Borch, K. (1962), 'Equilibrium in a reinsurance market', *Econometrica* 30(3), 424–44.

Mirlees, J. (1976), 'The optimal structure of incentives and authority within an organisation', *Bell Journal of Economics* 7(1), 105–31.

Quiggin, J. (1986), 'A note on the viability of rainfall insurance', *Australian Journal of Agricultural Economics* 30(1), 63–69.

Shavell, S. (1979), 'Risk sharing and incentives in the principal and agent relationship', *Bell Journal of Economics* 10(1), 55–73.

Singh, N. (1985), 'Monitoring and hierarchies: the marginal value of information in a principal-agent problem', *Journal of Political Economy* 93(3), 599–610.

Thompson, R. S. (1985), 'Risk reduction and diversification: an analysis of large UK multinational companies', *Applied Economics* 17(3), 529–42.