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RISK ANALYSIS FOR AGRICULTURAL PRODUCTION FIRMS: CONCEPTS, INFORMATION REQUIREMENTS AND POLICY ISSUES

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Is it Wrong to Fluctuate?: Policy Uses of Risk Management Research

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The first of the two parts of this paper considers how policymakers have actually used risk management research. It is short. The second part discusses the uses to which risk management research could be put in agricultural policy, if policy-makers chose to do so.

I. History of Risk and Policy

A natural place for risk management research in policymaking is in development of market stabilization programs and insurance programs. The paradigm market stabilization program is a buffer-stock program. This approach has been a key element of policy from the Federal Farm Board of 1929 through the ever-normal granary to the current Farmer-Owned Reserve Program. Insurance programs which make payments to farmers when prices or yields fall below legislated trigger levels have also been features of farm legislation throughout the 55-year history of U.S. federal commodity programs. Throughout this period agricultural economists have contributed (a lot of nonsense, but among it) some high quality, imaginative, and applicable ideas in risk management via farm policy. Examples are Waugh (1944) on consumers' interests in price stability, Johnson (1947) on reducing farmers' uncertainty through advance price signals, and Gustafson (1958) on how to establish socially optimal stock management procedures for grains.

I can detect no influence of these works on policy. Policymakers have continued to view price stability as an unmitigated boon to consumers, in exchange for which consumers should gladly pay a few billion dollars per year in program costs. Policymakers have gone nowhere with forward pricing, or in a more recent variant, price or revenue insurance. Policymakers have insisted upon maintaining crudely sub-optimal (if price stabilization is the goal) acquisition and release rules for government-owned and privately owned but subsidized stocks.

The reason for this record, I believe, is that policymakers have not been interested in stability or risk management. They have been interested almost soley in farm income support. The evidence for this assertion, in addition to the neglect of pure stabilization proposals, is that every farm program that has approximated a pure stabilization approach, like the Federal Farm Board, has died; and every program with stabilization elements that has survived has been converted to a price support or subsidy program, like the Farmer-Owned Reserve or the Federal Crop Insurance Program.

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The neglect by policymakers of stabilization as a goal does not mean of course that policies have had no effect on price or income stability. These effects are discussed in Brandow (1977) and in Gardner, Just, Kramer, and Pope (1984). The general findings in the few published studies of risk effects of policy are that the operation of most farm programs is stabilizing, but that uncertainty about changes in the programs themselves may have offset the stabilizing effects. The evidence on this is quite conjectural, but it seems evident that farm prices and incomes, and consumer food costs, have varied somewhat less in the post-1932 period as a whole compared to earlier history.

An important reason why agricultural economists have not provided more systematic analysis of the policy implications of risk is that the necessary underlying general economic theory has not been sufficiently developed. Policy analysis in the positive sense requires knowledge of income distribution effects -- who gains and who loses from risk in agriculture? Normative policy analysis requires a framework for choice among policy alternatives, which is usually based on welfare economics and benefit-cost analysis. In general economics, neither the theory of income distribution nor welfare economics is nearly as well developed for situations of risk and uncertainty as for the certainty case. Indeed in both areas, agricultural economists who have attempted to deal with the issues systematically have found themselves on the frontiers of economics. Writings cited above and to follow illustrate this.

Texts on welfare economics do not provide useful methods for assessing governmental activities under risk. The attitude of the "higher" theorists may be represented as a philosophical throwing in of the towel. For example, Nath (1969) recognizes the importance of uncertainty of the type of that confronts agriculture, and concludes: "This kind of uncertainty makes it impossible to be sure that any pattern of allocation which is at present considered desirable will still be considered desirable by the time it has been achieved. This is a kind of uncertainty conditioning human existence which simply has to be lived with with" (p. 60). Ng (1983), Rowley and Peacock (1975), and Brown and Jackson (1978) are recent examples of texts that say nothing about the topic without even an apology. Dasgupta and Heal (1979) and Newbery and Stiglitz (1981) emphasize the absence of forward markets and contingent (option) markets as a market failure, but not in a practically usable way. Cost-benefit analysis has taken risk more seriously as a practical matter, particularly in choosing the appropriate discount rate, but this isn't the issue in the agricultural policy area.

The work that provides the best available foundation for agricultural policy analysis under risk comes from two sources. The first is the literature on farm management and supply under risk; the second is market-level studies of optimal storage and price stabilization. Development in these areas are brought up to their current state of readiness to aid in policy analysis in Anderson, Dillon, and Hardaker (1977), Newbery and Stiglitz (1981), Just, Hueth, and Schmitz (1982, Ch. 11), Pope, Chavas, and Just (1983), and Wright and Williams (1984). In an attempt to spell out the current state of affairs, I want in the next section to discuss in elementary terms what the issues and questions are, and then consider what contribution the recent literature can make to clarifying the issues and answering the questions.

Agricultural economists have argued that stabilization through price supports can make (risk-neutral) consumers as well as producers better off because producers are risk averse, and therefore they will produce more when revenues fluctuate less. Thus we have a downward shift in the supply function and hence a lower consumer price. How do we measure the gains? In fact, are we sure that net social gains will be generated? If so, we don't have to be able to measure the gains quantitatively to make the policy recommendation that some stabilization program is a reasonable social investment. But there remains the problem of devising an operational risk reduction program.

In this section three aspects of this issue are discussed, as they relate to recent academic work on the economics of risk. This discussion is divided into three parts: first, measuring the social benefits of risk reduction; second, provision of the public goods which will achieve risk reduction; and third, market substitution for these public goods.

Measuring the social benefits of risk reduction

The most straightforward method of measuring producer gains is provided by Just, Hueth, and Schmitz (1982, pp. 255-262). Their measure of gains for a single competitive producer is shown in Figure 1. s_1 is the producer's supply function given an uncertain price, which is determined by a random process after production decisions are determined so that the producer responds to expected price. In order to focus on price uncertainty, assume that output is nonstochastic. (Price variability is generated by random changes in demand -- or foreign producers' output.) If the variability of price were reduced to zero, but its expected value remained at P, supply would shift to s_1, the producer would increase output, and the net gain to the producer would be measured by area a. Note that this is a gain in utility, not profits or economic rents as money returns. Indeed when uncertainty is present, profits exist equal to $(\bar{P}-C_1)$. q_1. But money profit is in this case a risk premium just sufficient at the margin to cover the disutility caused by uncertain prices.

The industry equilibrium is found by horizontal summation of all the producers' s_0 and s_1 curves, yielding S_0 and S_1 in Figure 2. At the industry level the market demand function must be incorporated. Mean price falls from P_1 to the equilibrium certain price P_0. Producers' gains if the market price had not fallen (if market demand were perfectly elastic) would have been A + B + C. But with the price decline to P_0, producers' surplus of E + B + C is lost. Thus, the net gain to producers is A - E. This can easily be negative. The less elastic the demand function, the more likely that producers will lose from stabilization.

The industry equilibrium change in figure 2 is identical to the supply-demand analysis of a technical change which shifts supply from S_1

to S_0. In that analysis it would be said that consumers gain area E + B, and that the social gain (the sum of producers' and consumers' gains) is A - E + E + B = A + B.

Area A + B is also the social loss from a production control program which shifts supply from S_0 to S_1. Thus, this simple supply-demand analysis of gains and losses places the welfare analysis of risk reduction on the same basis as the analysis of policies under certainty. The key difference is that where the standard analysis gives A + B as a deadweight loss from production controls under certainty, figure 2 gives A + B as the social gain from stabilizing price. This helps give an intuitive grasp of some policy issues. For example, it shows that if a supply control program has the same effect on supply function as an increase in risk, then if farmers gain (lose) from supply control, they must lose (gain) from price stabilization, i.e., if one of these programs is good for farmers, the other cannot be.

Having attained a conceptually simple and quantitatively tractable measure of gains from price stabilization when producers are risk averse, let us turn to the things that are wrong with it.

First, note that even if the model is appropriate, the measure of social gain to price stabilization is gross (as opposed to net). It is gross because the costs of the stabilization program must be subtracted, (just as the costs of generating new knowledge must be subtracted to get the social gain from technical change.) There will be costs to the stabilization program. The only way not to have costs would be for the government to operate a buffer stock at a profit or at least to break even. But the unregulated market equilibrium characterized by S_1 already incorporates the extent of stabilization created by private speculative storage. Equilibrium in private speculative storage occurs where expected profits are approximately zero.[1] Therefore added stocks in a stabilization program must drive expected (average) profit negative. So there will be some amount to subtract from A + B to measure the net social gain.

More fundamental problems with A + B as the social gain involve the model itself. Consider the gains to consumers, which were simply taken by analogy to technical change as equal to E + B. One problem is that consumers might be risk averse, too, so that stabilization makes them better off. This would show up as a rightward shift in the demand function when price is stabilized, hence generating more producer gains, perhaps more consumer gains, and more social gains.

Even if consumers are risk neutral, figure 2 does not tell the full story of consumers' gains. The curve D contains all the information about price at S_0, where price is stabilized, but the intersection of D and S_1 is not actually observed since it is random demand shocks that cause the uncertainty. In calculating producers' profits, the distribution of price can be replaced by mean price P_1 because producers do not respond to the random component if output is nonstochastic. But consumers can respond to short-term price fluctuations (unless our model introduces uncertainty by a mechanism such as a random-number generator in supermarket cash registers, with customers not permitted to alter their purchases after seeing the bill). This brings in issues of

Figure 1. Risk-averse firm

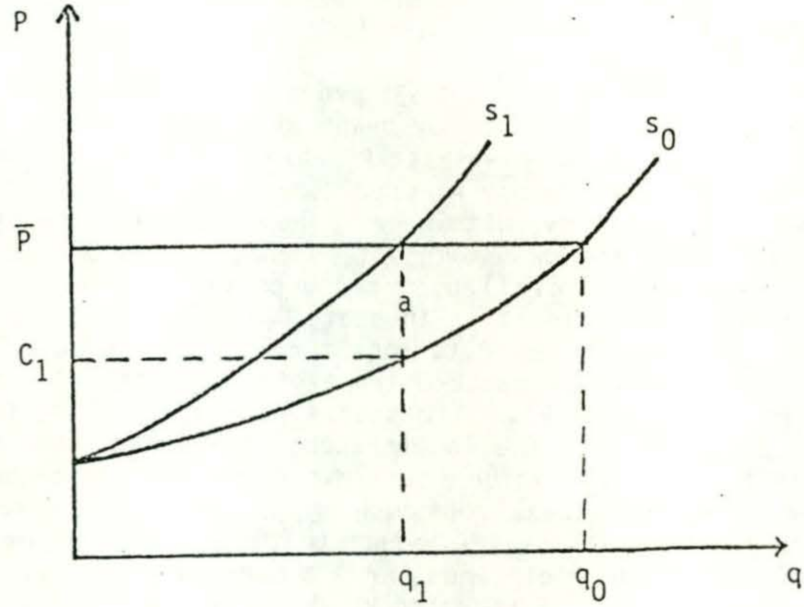
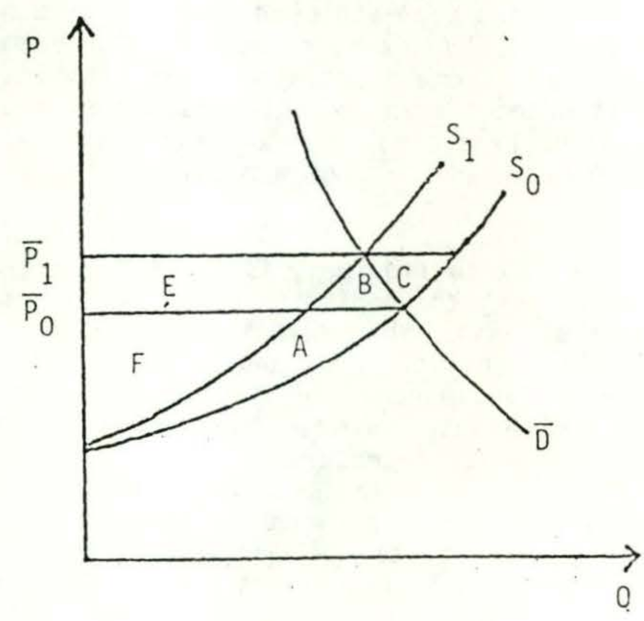


Figure 2. Industry of risk-averse firms



consumers' gains to variability as studied originally by Waugh. However, because the uncertainty is generated by shifts in demand, given quantity available, the ability to adjust consumption is created by the stabilization program, so that consumers will gain from stabilization (even if mean price stays constant). This means we have to add something to E + B to get the consumers' gain (and the full social gain).

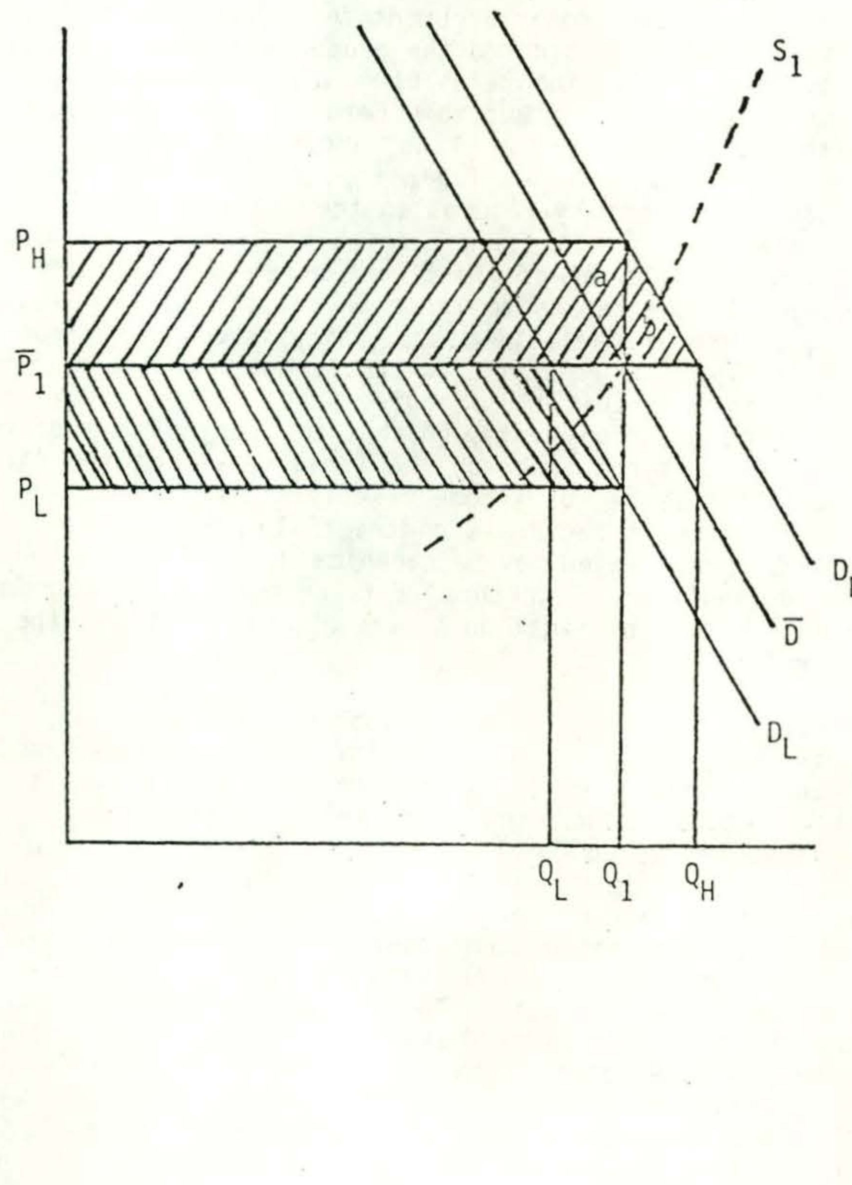
Just, Hueth, and Schmitz (pp. 260-61) provide an instructive example in which price is stabilized by means of a buffer stock. This permits consumers to buy all they wish at P_1 when demand is randomly high, but requires them also to pay P_1 when demand is low. The net gain to consumers from such a policy, with no risk response by producers is shown in figure 3. There are two states of demand, D_H and D_L, each with probability .5. Q_1 is always available, produced in response to P. Without stabilization, price is at P_H in state D_H. With stabilization via a buffer stock, Q_H is available to consumer at P_1. The gain in state D_H is therefore the upper hatched trapezoid. In state D_L with no stabilization, price falls to P_L. With stabilization, price P_1 is maintained, and consumers lose the lower hatched trapezoid. The expected consumer gain from stabilization is one-half the difference between the upper and lower hatched areas. Because D_H, D, and D_L are parallel, the difference in the hatched areas is equal to the parallelogram with area a + b, with 1/2 (a + b) = b. Thus, area b measures the net gain from pure stabilization via a buffer stock. This has to be added to E + B from figure 2 in order to measure the total consumer gain and to A + B in order to measure the gross social gains from stabilization with risk averse producers. In the Just, Hueth, and Schmitz example E + B is \$5 billion, A + B is \$4.5 billion, and area b is \$.25 billion.

Note that if stabilization had been achieved by a policy other than a buffer stock the area b gains would not have occured. For example, if D_H and D_L were generated by real income fluctuations and stability was achieved by social income insurance, then we would observe P_1 and Q_1 each year in figure 3 (ignoring producers' risk aversion) and there would be no area b gains. This shows that the mechanism used in stabilization is important.

Another issue, referring back to figure 1, is the intramarginal behavior of s_0 and s_1', particularly the depiction of s_0 and s_1 as having a common origin on the vertical axis. Why wouldn't risk aversion shift s throughout its length rather than rotating s around a point on the vertical axis? An economic rationale oculd be that when no output is produced, risk aversion is irrelevant. However, the intercept has economic meaning as the minimum price necessary to induce suppliers to produce any of the product. It seems reasonable that risk aversion should increase this minimum price. But perhaps the amount of income at risk is trivially small for small output? This raises the issue of how risk aversion changes with income, and also, apart from risk considerations, what is going on at small quantities supplied for an individual producer?

Two alternative ways of conceptualizing the supplier's situation are given by JHS and by Newbery and Stiglitz. JHS depict the supplier as a firm, with utility a function of profit, with profit defined as revenue minus variable costs, that is, the returns to fixed factors.

Figure 3. Gains from Stabilization



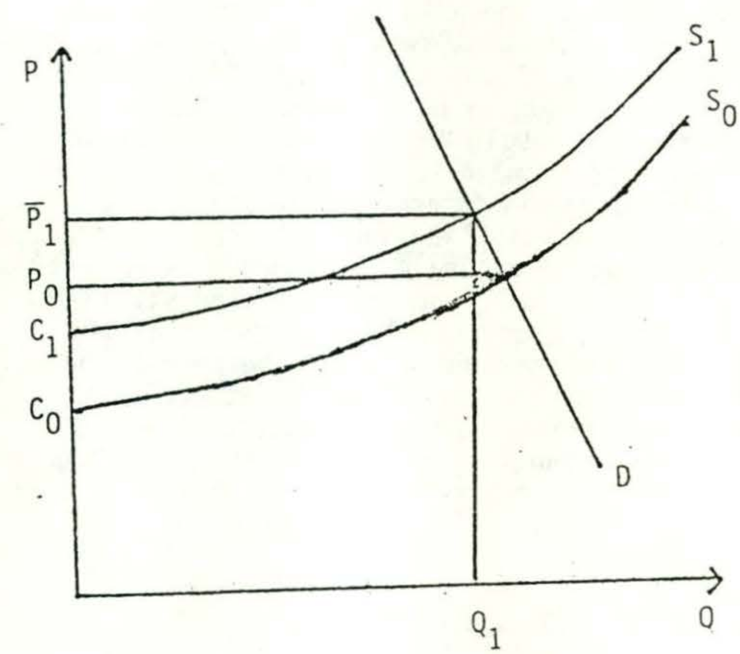
This means that the supply curve which is defined for fixed price (no risk) is the firm's short run (or whatever length of run fits with the input fixity assumed) marginal cost function. This means, for typical U-shaped average cost functions, that there will be a shut-down price, equal to average (variable) cost at its minimum. As price falls enough that q approaches the shut-down output, quasi-rents disappear, so by the same argument as above, the firm's supply curve rotates around the shut-down point. This makes it less likely that producers will gain from price stabilization as the area A + B is reduced.

However, it is necessary to consider the issue of whether quasi-rents (plus profits) is the proper argument for a farmer's utility function. What is usually considered the proper argument in an individual's utility function is (income usable for) consumption, or in an intemporal formulation, wealth. But some returns to fixed factors pay off past investments in equipment or land, and do not enter the consumption stream. Moreover, some variable inputs are the source of income for consumption, notably returns to the farmers' own labor. Labor is a variable input if the farmer can shift labor to other employment (another farm commodity or off-farm work or even leisure) in response to changes in the return to labor in the commodity being analyzed. So some part of variable costs, which is excluded from the surplus calculations, seems relevant to the farmer's risk position. On the other hand, it is true that if commodity price falls, the farmer must still pay the mortgage payments, so that the variability of returns to fixed factors, even if not owned by the farmers, affect the variability of income. The issue for income risk is not whether a factor is fixed or not, but whether a factor is contractually paid or is a residual claimant. Land rented may be technically a fixed factor but the issue for risk analysis is whether it is rented for cash or shares. There is no room for this distinction in the JHS approach and the approach is therefore suspect.

Newbery and Stiglitz (NS, Ch. 6) do not use the theory of the firm to develop their analysis of supply with risk averse farmers, and thereby evade these issues. NS consider farming as a labor-leisure choice, the risky returns then being labor income minus the disutility of labor. This enables NS to go into much more detail than do JHS about the nature of the utility function and how risk affects utility and behavior. But despite their use of a surplus concept, the net utility generated by effort, NS do not present their results in a way easily placed in a policy context, nor do they provide analysis for a farm firm that owns and rents nonlabor inputs. They do however provide empirically helpful linkages between risk aversion concepts and the concept of a risk premium in more detail than JHS. The risk premium is the amount that a farmer must be paid in order voluntarily to undertake risky production. It thus has a natural interpretation as a distance such as $C_1 - C_0$ in figure 4, and is conceptually compatible with the willingness to pay and compensating variation measures that underlie the JHS surpluses.

What we need for risk analysis of farm policy is the variability of net returns of all farm resources that are not pre-paid, and the risk premia required by their owners. With this information we can estimate the shift in supply caused by a risk-reducing policy. Then to compute

Figure 4. Vertically Parallel Supply Shifts



the market-level incidence of the policy we need the rents generated for all factors which are fixed or have upward-sloping supply curves to the industry, whether pre-paid or not. Thus, for example, the hybrid seed corn distributors supply a specific factor to corn producers and so earn rents which are included in the producer surplus areas above the market supply curves of figures 2 and 4. Yet because they are prepaid, their risk is not (directly) reduced by a corn price stabilization program. Consequently they do not share in the firm-level supply shift. This shows up as an aggregation problem -- horizontal summation of the firm's supply curves (for which seed prices are fixed) overstates the supply slope at the industry level.

Returning to farmers' returns in the JHS model, what is excluded in their quasi-rent formulation is returns to farmer-owned inputs which are upward sloping in supply but neither perfectly elastic (variable) nor perfectly inelastic (fixed), like the farmer's labor in the NS model. In this situation the firm's supply function may shift throughout its length when risk is reduced. Shown in figure 4 is a special case of vertically parallel shift in supply when risk is reduced. This outcome requires constant absolute risk aversion (CARA) if income is linear in P and the supply curve is linear, or more generally just the right degree of increasing or decreasing absolute risk aversion to offset nonlinearities in the relationships between P, Q, and income. The case of vertically parallel supply curves is interesting in that producers necessarily gain from price stabilization. To prove this proposition, consider the surplus areas of figure 4. Producers' surpluses are the boat-shaped areas below P_1 and P_0 for the risky and stabilized situations, and above S_1 and S_0, respectively. To show that the area below P_0 is larger, note that the constant distance between S_1 and S_0 means that $C_1 - C_0$ is the distance between S_1 and S_0 at Q_1. But the price decline $P_1 - P_0$ is less than the distance between S_1 and S_0 at Q_1 (the "cost" decline is greater than the price decline). This implies that $P_0 - C_0 > P_1 - C_1$. So if we integrate the surplus area for S_1 and S_0 up to Q_1, we find

$$\int_0^{Q_1}(P_0 - S_0(Q))\,dQ > \int_0^{Q_1}(\bar{P}_1 - S_1(Q))\,dQ,$$

because $P_0 - S_0 > P_1 - S_1$ at all Q. Moreover, producers' surplus for S_0 also includes the small shaded triangle to the right of Q_1. Thus, the producer gains A - E from figure 2 are always positive for vertically parallel supply curves.

Another aggregation problem arises because of the heterogeneity of farms. They have different shut-down prices, different contractual arrangements, and require different risk premia. They require different premia not only because they have different utility functions but also because they differ in diversification -- other commodities, off-farm work, income of family members, investments in non-farm assets. Moreover, farmers differ in access to credit markets which can smooth the consumption stream while income remains varible -- indeed with perfect credit markets there might be no risk premium at all. Such heterogeneity raises issues of measurement at the market level and of the economic meaning of what is measured. The measurement problem is that it is not reasonable to expect market-level gains and losses from policy to be deducable from individual-firm considerations as discussed earlier with reference to figure 4.

One can work directly with market-level demand and supply functions which are not the partial equilibrium curves which hold all other output and input prices constant, but are multimarket or "total" real income constant demand and supply curves in which all output and input price responses to a policy change are incorporated. The conceptual problem is of course that even if a surplus area provides a money indicator of utility for an individual, it cannot do so for a market since the transformation of money to utility can differ greatly among individuals. It still is reasonable though to speak of aggregate willingness to pay for (or to avoid) a policy change, and this is all one really needs to assess gains and losses of policy changes in just as rigorous a fashion as we can assess real income growth, say, in the farm sector or in an economy; that is, anybody who recommends giving up surplus or related CV or EV calculations as market welfare measures should also recommend abandoning our national income accounts. (This is my reading of the line of argument in Harberger, 1971.)

The practical issue in market-level welfare analysis under risk aversion is how to handle heterogeneity of utility functions when all measures of risk aversion are based on the first and second derivatives of the utility function. Moreover, there is a more serious problem than in the static case of heterogeneity in economic circumstances because with a proper portfolio of economic activities, a highly risk averse person might react to a policy change in a risk-neutral way, e.g., if the person has already hedged or bought an insurance policy. In this context willingness-to-pay measures have great appeal, as in the static case.

The natural willingness to pay measure for risk is the risk premium. Newbery and Stiglitz (Ch. 6) provide a good discussion of the concept in an agricultural supply context. They show that the risk premium, ρ, measured as the return necessary for a producer to accept a risky prospect with mean return $\bar{Y}$, is approximately

$$(1) \qquad \rho \cong 1/2\ A'\ \mathrm{Var}\ (Y)$$

where A is the coefficient of absolute risk aversion $(U''(Y)/U'(Y))$ for any twice continuously differentiable utility function $U(Y)$. In order to have a unit-free measure, NS also derive the more easily used expression for relative risk aversion,

$$(2) \qquad \rho/\bar{Y} \cong 1/2\ R \cdot C.V.(Y)^2$$

where R is the relative risk aversion coefficient, $\bar{Y} \cdot A$, and $C.V.(Y)^2$ is the squared coefficient of variation of Y, $\mathrm{Var}\ (Y)/\bar{Y}^2$.

Equation (1) is exact if Y is normally distributed, and is used in Anderson, Dillon, and Hardaker, and in JHS.

JHS (Ch. 11) integrate (1) into supply analysis for the firm, showing that with uncertainty in Y arising only from price, the risk premium is $1/2\ A\ Q^2\ Var\ (P)$, and that the firm's supply curve is shifted vertically by the marginal risk premium,[2]

$$(3)\qquad \frac{dP}{dQ} = A\ Q\ Var\ (P)$$

Dividing (3) by P gives the marginal relative risk premium. This is a conceptually handy indicator in that it tells directly by what percentage price has to be increased to offset risk aversion. Alternatively, it permits the forecasting of supply effects of a stabilization program from information on the risk premium, which in turn can in principle be estimated econometrically from farmers' responses to past changes in risk. Problems arise however in that (3) is defined for an individual and again there are problems of interpretating it in market data with heterogeneous firms. An industry may contain both high-cost firms with low risk premia, and lower-cost farms with high risk premia.

As an example of empirical work on risk in policy analysis, consider Thraen and Hammond (1983) on the dairy program. They estimate an econometric model of milk production in which investment in dairy herds and facilities responds not only to expected milk price but also to price risk. Price risk is measured for milk relative to crop prices by constructing a moving average of deviations of observed annual price from the trend price for both milk and crops (Thraen and Hammond, pp. 18-20). This variable has a significantly positive effect on investment in dairy production capacity which as specified implies risk aversion -- more variable milk prices shift the supply function upward as expected. The magnitude of the shift is so large that after adjustment to deregulation, the price of manufacturing milk is simulated to be 23 to 36 precent higher (depending on the pace of support price reduction) without dairy price supports then with price supports at the actual levels. Therefore, the policy conclusion is that consumers have gained substantially -- roughly \$3 per hundredweight times 1.2 billion hundredweight, or between \$3 and 4 billion per year -- from the existence of the price support program. (The fact that this study has not been cited by dairy industry lobbyists must mean either that the lobbyists have not seen it yet, or that they have seen it but haven't figured out what it says, or that they have seen it and have figured it out but that their distrust of academic economics is so complete that they won't cite studies even that favor the case for price supports.) Are the results believable? Since the support price holds the market price up in most years, the vertical shift in supply must have been even greater than 23 to 36 percent. Suppose it is 40 percent. Applying the JHS approach to the NS expression for the relative risk premium, this 40 percent is the marginal relative risk premium and is equal to

$$(4)\qquad \frac{d(\rho/P)}{dQ} = R \cdot C.V.(P),$$

substituting P for Y in the assumption that output is nonstochastic, which is the assumption in Thraen and Hammond. The risk aversion necessary to yield a value of 0.4 on the l.h.s. of (4) depends on the coefficient of variation in price that confronts producers. In the dairy simulations, price supports almost eliminate price variability around trend; with no price supports, the coefficient of variation of price around trend is about 0.1 (derived from a standard deviation of 85 cents per hundredweight and an average price of $8.90 during 1970-78). Thus, according to these results dairy producers have to receive a bonus of 40 percent of gross receipts (or roughly $4 billion) to induce them to undertake a risk characterized by a standard deviation of gross receipts that is 10 percent of mean gross receipts. This seems very high. Indeed from equation (4) it implies a relative risk aversion coefficient of $R = 4$ for the average dairy farmer. This is higher than in any of the studies surveyed by NS.

Econometric estimation of any interesting parameters usually raises as many questions as it answsers, and this is particularly true with risk aversion parameters. It is particularly important not to confuse supply response to risk with supply response to expected profit. This can happen when output is stochastic beacuse mean price will not measure mean revenue per unit sold if output and price are correlated. In this case the variability of price will be correlated with expected profit even though expected price is also a r.h.s. variable, which can easily lead to spurious "risk aversion" if the total revenue function is concave (e.g. if the demand function is linear). This issue is discussed in Gardner and Chavas (1979) and in NS.

Apart from the econometric problem, the dependence of mean revenue on price and output variability creates big problems for welfare analysis as in figures 1-4 above. The problem is that the mean price and output point will not be at the intersection of mean demand (D) and supply curves; and when we change price variability this will change the location of mean price and quantity relative to this intersection. This spells goodby to any simple graphical surplus areas in P, Q space. One can argue that the magnitudes of displacement, related to the curvature of total revenue and cost functions, will be second-order magnitudes relative to surplus areas, especially for comparative (stochastic) statics involving small policy changes. But these effects can easily be of the same order of magnitude as area b in figure 3.

Stabilization, Storage and Insurance as Public Goods

The preceding discussion follow the usual approach of analyzing price stabilization without much attention to the mechanism used to achieve it. Although the farmer's price could be supported by production controls, direct payments, or just passing a law that everyone must pay a minimum price, the mechanism typically invoked for stabilization is government acquisition of commodities at the support price. To analyze this activity fully, however, we have to consider the disposition of the commodities. To a first approximation, the sale of government stocks has a downward effect on price equal to the upward effect of the purchase of the stocks. Therefore, if every bushel purchased is subsequently sold, there is approximately no effect on the average price. Since almost all issues in stabilization turn on second-order effects, this is not a sufficient analysis. Wright and Williams (1984) provide results showing how the effects of price supports on mean price depend on the curvature of demand and supply curves. There is a large prior literature on stabilization summarized briefly in JHS (Ch. 11). It will not be discussed here because, unlike Wright and Williams, it does not model the storage regime but just assumes that variability is eliminated, mentioning storage as the mechanism. But every stockpiling regime will run out of stocks under some circumstances so that complete stabilization is impossible. Optimal stabilization cannot be specified without paying attention to the stochastic dynamic maximization problem involved, which this literature omits completely. The appropriate literature, stemming from Gustafson (1958) will not be discussed here. The optimal storage literature does not involve risk aversion and so fits less closely with the thrust of the S-180 project than the issues discussed earlier.

A related policy issue worth consideration is the status of stabilization as a public good. In a competitive storage market, equilibrium is characterized by the complementary inequalities,

$$E\,(P_{t+1}) = P_t\,(1 + i) + C \quad , \quad I_t > 0$$

$$E\,(P_{t+1}) < P_t\,(1 + i) + C \quad , \quad I_t = 0$$

where C is marginal storage cost, i is the interest rate, and I_t is the stock level in period t. The variability of prices over time when these conditions hold is the same as achieved by socially optimal stabilization via storage, as shown in Gustafson and subsequent studies. No risk aversion parameter is added because with an interyear futures markets, stocks serve a risk-reducing function for some crop producers, livestock feeders, and commodity users, so it's not clear that risk aversion implies a risk premium in stockholding.

Public storage beyond the competitive equilibrium quantities would invoke expected losses, but with risk averse producers there are gains such as area A + B in figure 2 that could more than offset the losses. The gains are a public good. All benefit but each individual benefits equally no matter who holds the money-losing stocks. This can justify governmental intervention for stabilization purposes. Indeed the U.S. government currently provides this service not only for the U.S. but for the world grain markets.

It is doubtful, however, that price stabilization by means of stockpiling is a first-best means of providing this public good. The producers' aversion is to variability in returns, so that shifting money from periods of plenty to periods of scarcity would be just as effective in reducing risk, and cheaper, than commodity storage. But then the question arises of why producers do not buy insurance policies, hedge on futures or options markets, and stabilize consumption via credit. If the appropriate insurance policies or option contracts do not exist, then it seems more straightforward for the government to establish and supply the appropriate risk transfer contracts. This approach to policy suggests a corresponding approach to economic analysis of producers' risk aversion, namely to measure the surplus area as the area under the demand function for insurance.

Perhaps one reason why policy issues in risk have not been discussed more often in terms of supply and demand for insurance is that simple supply-demand models of insurance have not been developed. A problem that arises immediately is specifying the appropriate quantity of insurance. One could adapt figures 1-4 by identifying the quantity of insurance with the amount of expected revenue covered. But this leaves unspecified the coverage level; for example, one could specify the expected dollar value of a farmers' corn crop as $100,000, but this would not determine the "quantity of insurance" the farmer bought -- for this we need to specify the hazards insured against, the amount of loss that triggers an indemnity, and perhaps such details as deductibles.

Consider a specific insurance contract -- price insurance which pays an indemnity equal to the difference between the actual (Chicago Board of Trade) market price and the (pre-planting) expected CBOT price whenever the harvest season market price falls 5 percent or more below the prior expected price. This is a straightforward contract to consider in that it is equivalent to a put option on futures purchased in the pre-planting season which expires in the harvest season and has a striking price 5 percent below the planting season futures price. The analogy permits a clear conceptualization of the price of the insurance policy as equivalent to the premium on the put option. On March 13, 1985, CBOT corn futures for December 1985 were priced at $2.62 per bushel, and put options with a striking price 5 percent less, at $2.50, were priced at 4.5 cents per bushel. The right to sell at $2.50 in December is equivalent to an indemnity payment equal to the difference between $2.50 and the actual December price. Since $100,000 of corn is about 40,000 bushels (8 contracts of 5000 bushels each), the farmer's price paid for the price insurance policy on the crop is $1,800. (The equivalent contract for $100,000 of soybeans was selling on March 13, 1985 for about $2,500, presumably because of the greater volatility of soybean as compared to corn prices, hence the greater probability of indemnity payments being made on soybeans.)

The price paid for the price-insurance policy determines a supply-demand equilibrating point, but how to analyze other points on the demand and supply functions for insurance, and how to construct surplus measures is not so clear. The most disaggregated approach is to consider the supply and demand for a particular contract by a particular person. In a competitive insurance market the policy would cost the actuarial value of the expected indemnity payments plus the insurer's administrative costs, assuming the insurer has a diversified portfolio of policies or reinsures such that the insurer requires no risk premium. This is what the farmer would actually pay. The farmer's willingness to pay is measured by a point on an all-or-none demand curve -- the lowest price of the insurance contract at which the farmer chooses not to buy insurance. The vertical distance between the all-or-none demand curve and the market price, times market quantity (one contract) is the farmer's surplus from having the contract available. This links the surplus concept for insurance with standard consumer surplus concepts (Patinkin 1958) and with the input-market approach to producers' surplus in Pope, Chavas, and Just.

In considering changes, necessary to do comparative statics, one approach would be to replicate the number of contracts. This would be too large for a marginal change for an individual farm, but the approach makes aggregation over individuals straightforward. We add horizontally the all-or-none demand curves across individuals -- who in general will have quite different willingness to pay -- and the curve to which the aggregate all-or-none demand curve has the relationship of average to marginal will be the market demand curve for insurance (Patinkin, pp. 83-86), the area under which and above price is the aggregate surplus measure for producers due to the risk reduction provided by insurance. The problem with this approach is that it assumes only one insurance contract is available.

A second approach is to generate marginal changes in the contract. This can be done by changing output covered, changing the price that triggers indemnities, or changing other characteristics of the contract. Changing output covered fits with Q from a supply function but doesn't really get at the marginal change in risk that is of central interest. Changing the insured (striking) price seems more appropriate, but it also omits important possibilities. We could for example reduce risk by a smaller mean - preserving spread in price, ultimately eliminating all risk by means of a forward sale. (Question: Would a forward sale always generate more surplus than any insurance policy for a producer whose utility function was globally concave in income?

Market Substitutes for Stabilization Policy

Several market means of risk reduction have been mentioned -- insurance policies, forward contracting, futures and commodity options, credit markets, private storage, enterprise diversification, and off-farm income. A problem with public stabilization programs is that they reduce the supply of these services. This is well documented for the effect of public grain stocks on private storage, and is apparent in the market for put options in price-supported commodities (why buy price insurance when the government gives it away). A general issue along the same line is that public stabilization blunts the incentive to invest in information and flexibility that are necessary to respond to emerging changes in economic conditions.

The policy relevance of uncertainty is not just a matter of providing public-good stabilization services needed because of random crop yield or demand. Cyclical and longer-term shifts in markets are also important in agriculture, as elsewhere. Much of the entrepreneurship in modern farm management, especially financial management, involves detecting and adjusting to these events as they are revealed. The problem for policy is to avoid spoiling the market for these skills.

Consider the following statements about the housing construction industry:

> To call home building a boom-and-bust business is to put it mildly. More than 35,000 builders -- 28% of the total -- dropped out in the last bust, which began in November 1978 and lasted for 36 months.

> "It was a miserable recession," Michael Sumichrast, chief economist of the National Association of Home Builders, says of the worst housing slump since World War II. He says that the bankruptcy rate in the construction industry at that time was the highest on record.
>
> Those builders who survived are now operating much differently than they did before the slump.[3]

Agriculture, too, has strong boom-and-bust elements, most recently exhibited in the bust of 1980-84. Comparison of housing and farming suggests a troubling contrast, though, in that our farm policies in response to the bust have provided obstacles to farmers operating (financially) much differently than they did before. Indeed, the general rationale of the policies seems to be the following: a number of farmers, through no fault of their own, now find themselves in sad financial straits; therefore, we should take those steps necessary to buffer the losses and keep the farmers in business. The drawback of this approach is that its goal of causing farmers not to have to regret disastrous financial decisions results is revealed as a goal of permitting farmers operate in an unchanging manner regardless of changing circumstances.

The analytical issue here involves the economics of supply of managerial skills.

[1]"Approximately" because private stockholders may not be risk neutral. The risk premium, if one exists, may be positive or negative. It depends whether speculators in stocks are risk averters or risk preferers, and whether holders of stocks are speculators or hedgers (hedgers here are people for whom the addition of commodity stock to their assets reduces the variance of returns to the whole set of assets, e.g., millers or livestock feeders).

[2]Actually, JHS use a risk parameter α, which is related to the parameter A as: $\alpha = 2A$. Anderson, Dillon, and Hardaker (Ch. 6) provide a more general analysis which shows that the parameter α is the slope of the indifference curve between variance and return, and use α in an input demand relationship. Pope, Chavas, and Just (1983) find that surpluses in input price-quantity space are appropriate for measuring gains from risk when production is stochastic, an issue well explored at the firm level by ADH.

[3]S. L. Jacobs. "Builder Heeds Lessons Learned Surviving Last Housing Slump." Wall Street Journal, Nov. 19, 1984.

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