WHAT DO WE KNOW ABOUT AGRICULTURAL PRODUCERS' BEHAVIOR UNDER PRICE AND YIELD INSTABILITY?

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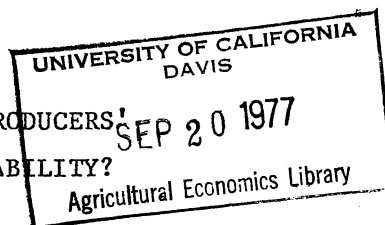
Introduction

I interpret unstable prices and yields to imply uncertain prices and yields. One could imagine a situation where controlled prices were announced well in advance but fluctuated according to perceived circumstances at the times of the announcements. Some agricultural programs have approximated the latter, but I take it the main interest here is in supply response with price unknown at the time production and tentative marketing decisions are made.

In considering producer behavior in the United States, it is worth noting that 70% of cash sales are furnished by the 450,000 farms (16%) having sales of $40,000 or more. On the average, each operator in this group controls nearly a million dollars worth of farm assets. Thus supply response is principally determined by the executives of a group of highly competitive, respectably-sized businesses. Direct observation supports the theoretical conjecture that survival or growth in such businesses requires intelligent, industrious, informed managers. So the mental image I have of the party whose decisions we want to understand is that of an alert, sophisticated person continually mingling physical and supervisory tasks with a wide assortment of calculations, and with gathering and sifting a variety of relevant information.

Difficulties in Achieving Firm Knowledge

Our knowledge of the decision-making processes of these farmers comes primarily from three sources:

(1) experiences of people who work closely with farmers - feed dealers, implement dealers, extension workers, buyers, etc. including farmers themselves;

(2) theoretical models of behavior;

(3) econometric studies.

Interdependencies between the sources are clear. Advances in each are made by drawing on the other two. For example, a good econometric model builder tries to plausibly represent important judgments of experienced people and to reproduce aspects of the more promising general theoretical models. His results then provide some evidence as to the validity of the judgments and the relevance of the theories. Many extension workers and agribusiness trainees study theory and consult econometric studies to interpret their experiences more coherently.

To make a specific appraisal of how much we know about producer behavior under uncertainty would indeed be a formidable task. It would involve testing the forecasts of experienced people and the best models we could construct as well as forecasts by people of good judgment with access to all sources. An important question would be the relevance of past experience and analysis to a situation changed by such factors as changing impacts of government programs, increased contracting, changing international trade policies and patterns, etc.

I haven't the resources to make such an appraisal and am inclined to doubt that a large undertaking would be the best use of research resources now. I think we can all anticipate that the forecasting record would be sufficiently mixed and tests of econometric models would reveal sufficient possibilities of sampling and specification error that

the pressing need we feel to improve our understanding would be reinforced.
I would therefore like to turn my attention to some possibilities for
improvement.

The possibilities are numerous and some very perceptive people dis-
agree on what is most promising. Let me label what follows as one person's
opinions without implying that any of the opinions are new.

Further development and empirical exploration of expected utility
models of producer behavior seem promising avenues at this stage. Studies
like those of Officer and Halter [9], Lin, Dean and Moore [8], and Just
[6] tend to confirm our notions that farmers are predominately risk averters.
One expects this to lead to somewhat lower output than if average prices and
yields could be known and stable. However, this tendency must be partially
offset by loss shifting provisions of tax laws and investment credits. To
further test our current notions and to obtain more precise relations,
extensions and modifications of such studies should be undertaken.

Before making some specific suggestions, I should like to note two
relevant developments.

Related Developments

It has properly been asserted that financial gain is not the only
incentive shaping human behavior. Social status, religious values,
domestic tranquility, leisure and aesthetic enjoyments might immediately
be cited in the case of our producers. This has led to analysis of multi-
attribute utility models in which the expectation of a function of several
variables is presumed to be maximized. Keeney and Raiffa [7] have prepared
a stimulating exposition of such models and experiences with them. Cer-
tainly such models for agricultural producers should be formulated,
analyzed, and tested.

However, it is my conjecture that when this is done, it will be found that the narrower utility of monetary gain model will be a useful approximation in many instances related to year-to-year supply.

My impressions from introspection and from recent interviews with a panel of Minnesota farmers (work partially supported by ERS and not yet reported) is that nonfinancial considerations typically enter very importantly into the decision to farm and the decision of the kind of farm to organize. Once these decisions are made, I suspect that financial considerations dominate most of the year-to-year production and marketing decisions so long as the basic organization of the farm is not reconsidered.

Of course it is to be expected that personal tastes will be indulged when the financial considerations are not large. A farmer who has fed Holsteins (there are dairy herd liquidations in his area) for several years remarked last spring, "I'll be glad when I can go back to beef steers, they're nicer to watch." However these motivations are not apt to affect supply relations greatly.

For me, the upshot is that it seems desirable to start developing multi-attribute models for some aspects of producer behavior, but I would not like to see this interrupt further development of financial gain models in appropriate settings.

Another relevant line of thought worth noting is associated with topics like satisficing, adaptive economics, bounded rationality [1]. Very loosely, a decision-maker typically has a variety of goals. He formulates a more or less precise strategy that seems to offer the chance of substantially achieving these goals and proceeds.

As long as achievement is substantial, the strategy is likely to be

retained. When sufficient disappointment accumulates, a search for a new strategy is undertaken. A complete ordering of outcomes is not always assumed. Traditional economic theory is too rigid and narrow in postulating a precise individual equilibrium that maximizes utility or expected utility.

Even in the above garbled version, I agree that the approach has considerable merit. I still see, however, considerable promise in the further development of expected utility theory in contexts in which the decision-maker may be expected to closely comply with the axioms which permit an expected utility representation (see Fishburn [2] for a reformulation and brief historical sketch).

Consider the following possibility. Global lifetime decision-making (Savage's [10] grand world) is perceived as proceeding according to some meta-model which might or might not be Bayesian. Within the meta-model the decision-maker sometimes formulates (or acts as though he formulates) expected utility models of specific decision problems (Savage's small worlds).

One function of the meta-model is to indicate when smaller models are to be reconsidered. Reconsideration might include - (1) states of nature regarded as possible and the prior distribution of states; (2) the flow of information used to successively form new posterior distributions and the statistical models used to interpret new information; (3) the space of possible actions; (4) the relation specifying a consequence for each state-action combination; (5) the decision-maker's perception of his utility function.

A possible advantage of the expected utility framework for small problems is that the kinds of difficulties encountered may provide hints of promising reexaminations. Two cases are obvious. If states of nature that

were not contemplated occur, the state space has to be broadened. If realized outcomes do not yield the anticipated satisfaction, the utility function is not well articulated.

Assuming neither of the above, realized utility may still not agree very well with expected utility. Once an action has been chosen, the decision-maker has a subjective distribution of outcomes and a subjective distribution of possible realized utilities. For convenience call these the final distributions. If realized utility is consistently low - say it is consistently below the mean of the final distribution - this suggests difficulty in the expectation formation process. Better information may be needed; the statistical model through which information is interpreted should be tested; the decision-maker may be using a very precise prior that does not respond to new information.

On the other hand, it could happen that realized and expected utility tend to agree pretty well over time but both are consistently low. Optimal plans just don't provide much chance for happy outcomes. In this case the available actions would seem to be a logical place to start reconsidering. If modest reconsideration does not yield something helpful, actions like hiring a consultant or going out of business might be contemplated.

I think the above might be described as common sense in special jargon. If Bayesian models lend themselves to using common sense this seems to the good, and it is to be hoped that in specific contexts the kind of trouble-shooting described might lead to more specific remedies than unaided common sense. So my current reaction to the satisficing-bounded rationality development is that it appears interesting and worthwhile, but not inconsistent with the continued useful development of familiar expected utility models in suitable contexts, including aspects of supply responses.

Improvements in Expected Utility of Wealth Models

Assuming there is a wide range of agricultural supply problems to which expected utility of gain or wealth models can be usefully applied, I have several suggestions for the continued development of such models.

Mean-Variance. It has been recognized from the outset that the choice which maximizes expected utility will lie on the efficient mean-variance frontier only in special cases. Quite a few investigators have, however, conjectured that analysis in terms of mean and variance might frequently yield approximately optimal decisions and have continued to use this approach. It seems to me that we need to broaden our approach, to test mean-variance analysis against alternatives and to use it only when there is good reason to believe that it does furnish a suitable approximation.

Form of Utility Functions. Use of mean-variance has frequently been accompanied by polynomial utility functions. Polynomials have the distinct disadvantage that behavior of the function for large values of its argument is determined by the sign of the coefficient of the highest order term. Both alternatives are implausible. If the coefficient of the highest order term is positive, the polynomial is, and remains, convex for sufficiently large wealth; if the coefficient of the highest order term is negative, the function becomes downward sloping - less wealth is preferred.

One can claim that a particular polynomial is a good approximation to utility in the relevant range. The difficulty is that the relevant range depends on the particular alternative choices contemplated. Changing these involves changing the relevant range and having to reverify and possibly change the utility function.

Keeney and Raiffa report several increasing, concave functions that permit decreasing absolute risk aversion. Among those reported are

$$(1) \quad u(x) = \sum_{1}^{N} a_i \, e^{-b_i x}$$

$$(2) \quad u(x) = a + b \, \log(x + c)$$

$$(3) \quad u(x) = a + b \, \log(x + c - d|x|)$$

$$(4) \quad u(x) = a + b \, \log(x + c - d[(x^2 + f^2)^{\frac{1}{2}} - f])$$

$$(5) \quad u(x) = a + b \, x^c$$

I have occasionally used

$$(6) \quad u(x) = ax - b \, e^{-cx}$$

which is simple and also has the properties usually sought.

We should, of course, continue to check the possibility that utility functions have convex regions. My own current conjecture is that risk aversion probably dominates business decisions. An argument tending to support this conjecture is given in the appendix.

Initial Prospect. Particular decision problems are never encountered in a vacuum. While a decision-maker deals with uncertainties associated with some aspects of his life, other uncertainties exist and are typically relevant to his current decisions. It seems reasonable that uncertainties in livestock enterprises should be relevant to a farmer's crop decisions. His holdings of securities are relevant to all of his farm planning. I have called these background uncertainties the initial prospect [3], [5]. It turns out that the initial prospect does not have to be explicitly taken into account if it is known to be statistically independent of the ventures currently considered. Whether or not this is the case needs to be carefully considered in each application.

There are, of course, hosts of other problems that require early attention. Multi-period models, effects of the tax structure, and the process of expectation formation are immediate instances. Finding things that need doing is not a current problem. As models of producer decisions become more complete

and more firmly established, they will have implications for econometric models of market behavior and for models of public decisions. For example, a frequent assumption in econometric models is that expected price is a linear function of past prices with coefficients following some predisposed pattern.

In early July, I found several beef feeders uniformly optimistic about next summer's prices. More adequate feed to halt herd liquidation was the principal reason. Expected improvement in the general economy was next. I can't help wondering how well the historical price sequence captures such considerations. With regard to public decision, a large part of the Keeney-Raiffa volume cited earlier is concerned with extending expected utility reasoning to this realm.

References

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Appendix

Suppose Mr. A has the Friedman-Savage "typical" utility function shown in Figure A while Mr. B. has the concave function of Figure B. The latter is similar except for the linear segment over $[x_1, x_2]$.
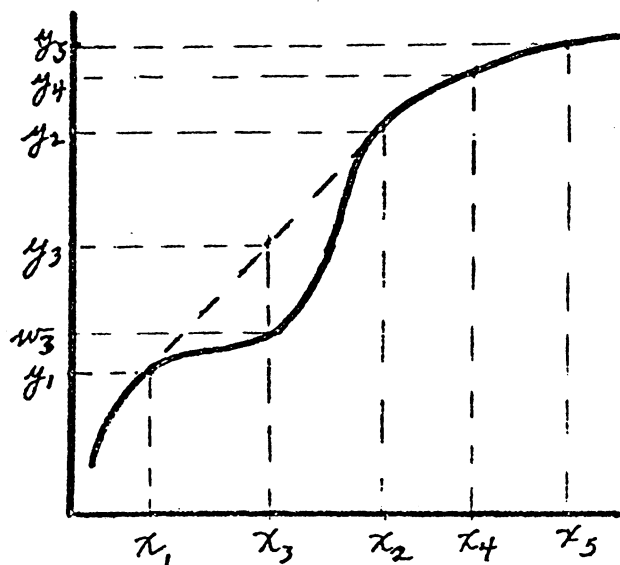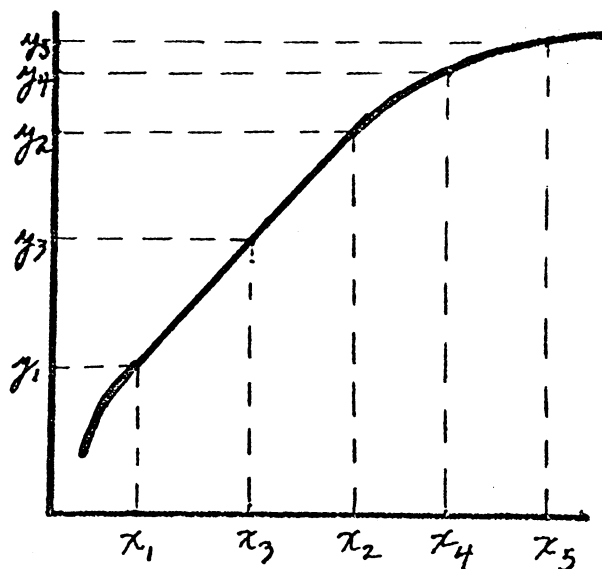

Figure A

Figure B

Suppose A and B can place fair bets with arbitrary probabilities and appropriate stakes of size $x_2 - x_1$ or smaller. If A finds himself with wealth x_3, he can quickly achieve expected utility y_3 by placing a bet that will pay $x_2 - x_3$ if an event with probability $\dfrac{x_3 - x_1}{x_2 - x_1}$ occurs and will cost $x_3 - x_1$ if not. Thus we expect to observe A at x_3 only momentarily.

Now suppose A and B are both at x_4 and each is considering a venture which will gain $x_5 - x_4$ or lose $x_4 - x_3$. If p is the probability of success, then B's expected utility if he pursues the venture is $py_5 + (1 - p) y_3$ and he will pursue if and only if $p > \dfrac{y_4 - y_3}{y_5 - y_3}$.

If A reckons in terms of his utility of wealth function his expected utility on taking the venture is $py_5 + (1 - p) w_3$ and he will pursue if and only if $p > \dfrac{y_4 - w_3}{y_5 - w_3} > \dfrac{y_4 - y_3}{y_5 - y_3}$. However, if A thinks one step ahead and recognizes that he will quickly take the previously noted fair bet if he does land at x_3 then his contemplated expected utility under the venture is $py_5 + (1 - p) \dfrac{x_3 - x_1}{x_2 - x_1} y_2 + (1 - p) \dfrac{x_2 - x_3}{x_2 - x_1} y_1 = py_5 + (1 - p) y_3$ which is the same as the contemplated utility of B. Thus, starting from x_4, and assuming that A's potential bets depend on an event independent of the venture being considered, A and B will accept exactly the same ventures. Their behavior will be indistinguishable except that A may sometimes be detected making supplementary fair bets after observing the outcomes of his ventures. It is easily verified that this is true regardless of starting point.

In our economy there may not be fair bets of every desired size and odds. However a very wide assortment of nearly fair prospects is surely available from Las Vegas, commodity futures, commodity options, stock options,

foreign currency, and many less exotic business opportunities. Note that if purchasing a commodity future is an unfair prospect then selling it can be unfair by at most transactions costs which are small.

Our sophisticated producers who mainly account for fluctuations in supplies of farm commodities must typically be aware of some of these opportunities. In some cases the potential bets are not independent of contemplated ventures as for example a wheat farmer whose venture is expansion and whose contemplated bets are wheat futures. Dependence can be better or worse than independence and needs careful exploration (this is stressed in [4], [5], [6]). Note that if he desires, the wheat farmer can get an independent or nearly independent bet by using Congo currency. Also note that A could, for practical purposes, convert a purchase of a commodity future into an $(x_2 - x_3)$ vs. $(x_2 - x_1)$ bet by arranging to close his position as soon as he had either made $x_2 - x_3$ or lost $x_3 - x_1$.

Modified models that more completely reflect circumstances of particular kinds of entrepreneurial situations should be examined, but I believe these considerations establish a presumption that convexities lying between concave segments in a pure utility of wealth function may be taken to be substantially "filled in" when business ventures are contemplated.