

DISCUSSION

THE LIMITS OF UNCERTAINTY: A NOTE*

ABSTRACT. Discussions of decision making by individuals and organizations invariably touch on the issue of uncertainty. Decision theory axiomatizations are based on the assumption that uncertainty cannot be unlimited, but that there must exist a minimal interval of value stability. This note makes explicit that assumption for individual choice. For group and organizational decision making, a proof is presented which deduces a limit to uncertainty from the existence of deliberate social action.

All discussions of decision making and modern organizations are forced to come to grips with the question of uncertainty (Thompson, 1967, p. 159; Mack, 1971, pp. 1–6). What is not always obvious is that there must be – if only implicitly – an assumption concerning the limits of uncertainty without which concepts like society, policy, and decision cannot be meaningfully used. It might be of interest to make this assumption explicit.

Using Thompson's categories of instrumental uncertainty ('uncertainty concerning causal relationships') and value uncertainty ('uncertainty about preferred outcomes') (1967, pp. 134–135), we may equate a situation where both these are high with a turbulent social environment, when both means-ends relationships and values are in rapid transition and renegotiable between organizations and institutions (Emery and Trist, 1965; Terreberry, 1968; McWhinney, 1968). Such situations, though described by Thompson as untenable for any length of time, are today not so uncommon (Friedmann, 1971, p. 319; Alexander, 1972, p. 326) and call for an appropriate response by the decision maker and the societal unit.

One such prescription might be to maximize adaptability (Biller, 1971; Mack, 1971, pp. 88–89, 189–195; Friedmann, 1973, pp. 171–193). An organization structured for quick reaction to unforeseen exogenous influences can accept a high level of uncertainty by keeping its options open and not implementing any policies the effects of which extend beyond the time horizon of known value certainty. Thus, as change and uncertainty increase, the planning horizon must of necessity contract.

Another possibility, consistent with the above, is for the societal unit to encourage risk taking by its leaders for those decisions which are needed to sustain its basic values. Such risk propensity might, by increasing the proliferation of policy 'mutations', improve the survival capacity of the social organism in a hostile environment.¹ Adaptability of the organization would make unsuccessful policy endeavors expendable with a minimal loss in social costs.

Both the above prescriptions, however, are based on the premise of a limit to uncertainty, as indeed is any prescription of individual and social action. In fact, all the generally accepted decision axiomatizations assume – explicitly or implicitly – a limit to uncertainty, and at least the persistence of the decision maker's values over some unspecified time period. In his classical exposition of individual decision theory Marschak (1954, p. 27), when defining the 'utility of a prospect', assumes that the decision maker's preferences will remain stable between the time of his choice and the time of the realization of that prospect. This is made quite clear in his distinction between normative and descriptive statements about human choice, both of which are empty "if the ranking order is not supposed to be stable over a period long enough to make the statement of practical relevance" (Marschak, 1968, p. 430).

Fishburn's axioms for individual choice under uncertainty share the same assumption (1973, pp. 237–242). For instance, where he deduces probabilities from preferences (1972, pp. 78–79) he assumes a constant utility of the payoff function between the time of the gambler's decision and the realization of the expected events A or B in $f_A > f_B$. To use his example, if gamble f_A is a prize of \$1000 if A obtains, and gamble f_B is a prize of \$1000 if B obtains, then $A > B$ 'if and only if $p(A) > p(B)$ ' but also if the utility of \$1000 has not changed for the player between the time of the decision and the payoff. However, if an independent event associated with A (but totally unanticipated by the player) threatens him with foreclosure if he does not come up with \$1000, and another such independent event – say, the death of a maiden aunt – will turn him into a millionaire just as B obtains, so that the utility of the prize in the two cases becomes very different – then it cannot be inferred that $A > B$ only if $p(A) > p(B)$. This element of uncertainty – the difference between *a priori* and *a posteriori* utilities, is the basis of many stories of tragic wish-fulfillment, such as Balzac's *Peau de Chagrin*.

In his 'Generalization of Classical Decision Theory' Leinfellner (1968, pp. 199–200) offers a set of axioms which also share this assumption. His axiom A1, which establishes a 'quasi-ordering' of indifference and preference, implies the persistence of these relationships over a certain time interval, as does his axiom A9, involving the addition of a constant to expectations of a gamble. Though his theory purports to accommodate a higher level of uncertainty than classical decision theory, Shackle, too, operates under the assumption of value persistence from the time of the decision maker's choice – a time he defines as his 'viewpoint':

When we speak of the preferred blueprint B_i out of the set of blueprints which would become available if E_i were to turn out to be the intermediate event, we mean of course, the blueprint preferred in the light of the expectations held by the decision maker *at his viewpoint*. (1969, 213, original italics)

Even decision making under ignorance, where uncertainty is so great that not even equal probabilities can be attached to outcomes, but all states of nature have 'zero potential surprise', shares this assumption (Arrow and Hurwicz, 1972, pp 2–3). Here "an action (is) defined by its consequences under each alternative state of nature," so the value of an action is actually the utility of its consequences to the decision maker – a concept which makes good sense but implies the decision-maker's expectation that his values will be the same when the consequences make themselves felt.

Moving from the realm of individual decisions to the arena of inter-personal decision making and societal choice, we again encounter an avoidance of situations where the decision unit's value perspective perhaps approaches zero. Game theory from its very inception consisted of a series of static one-period models, assuming the durability of roles and preferences through the entire interval of such a period (Shapley and Shubik, 1971, pp. 16–18). And in the area of societal decisions Arrow, in his classic work – after building on a construct of axioms from individual decision theory – defines a social welfare function as a process or rule which establishes a preference ordering of social states for a societal unit corresponding to a given set of individual preference orderings (Arrow, 1964, pp. 13–23). The inference is unavoidable that these individual orderings must remain stable through the specific process, and that the social ordering must be expected to persist at least through the interval between its determination and the realization of the social states

involved. The same assumption is shared by Fishburn (1973), where many of the social preferences referred to are expressed by voting.

How short can this stability interval become – that is the question, both for individuals and other units of social choice. What must be the limit of uncertainty if decision making is to take place at all, in a non-trivial sense? This is a question which is as pressing for individuals as for social decisions, but needs to be addressed separately for these two classes of choice. The question of instability of individual utilities has been addressed by von Wright (1972) who discusses the problem of the relativity of a preference scale to a particular subject at a particular moment in time.

Menges sees the instability of the decision situation as posing an insuperable obstacle to the empirical application of decision theory on a wide scale to social issues (1968, pp. 144–151). Both introduce the concept of a time interval over which the decision situation and the decision maker's value system have to be assumed as stable – a concept of which I too will make use below. An example (rare, I suspect) of explicitly changing utility functions is offered by Peston (1967), but this can hardly be regarded as an incorporation of uncertainty into the decision analysis, since the changes in values are assumed to be continuous and decomposable, and therefore quite predictable.

For societal decision units – groups and organizations – the question is: how short can the planning horizon of a unit become, and how adaptable can it be, and still retain a recognizable identity? Must there not be some certainty, of however a fleeting kind, about a minimal set of values which inform those decisions concerning which risk might be worthwhile? Can there be a state of complete flux, where uncertainty about causes and disbelief in values is absolute?

That there is a limit of uncertainty about values may be shown as follows, given only the assumption that values exist – in any objective sense – only as they are manifested in actions. Then, if a given decision is expected by the agent to have an effect over a period of time T_a ($0 < T_a \leq \infty$) the expected time perspective for the value or set of values which is manifested in that action (T_{vt}) must be at least equal to T_a . In other words, the time for which the value is expected by the decision-maker to persist at time t when the action is initiated cannot be shorter than T_a : $T_{vt} \geq T_a$.

The above deduction is based on the recognition that a decision-maker will not do something that reflects a set of values about which he already knows – at the time of his consideration of the issue – or senses a reasonable probability that he is likely to change his mind during the time of the effect of his decision. Obviously, he may make a decision and later amend, discard, or reverse the set of values on which that decision was based, but at the time he was making the decision, if he was acting as a reasonable man, he must have expected those values to persist.²

This is as far as we can go in the area of individual choice and values. It is an extension of the proposition advanced by Menges (1968, pp. 151–152) who distinguishes between the time needed for the decision process itself and its realization – which he calls the ‘process interval’: G , and the period over which the decision situation remains stable, defined as the ‘stability interval’: T .

If the process interval G is included by the stability interval T , then the empirical situation is obviously equivalent to the situation assumed in theory. (But) As the process interval becomes longer and the stability interval becomes shorter, the empirical situation departs from the assumption of the model.

However, Menges sees the main factor limiting the stability interval as variations in probability distributions in the decision situation, thus limiting the problem of uncertainty to a challenge of prediction. Here, while we have established the concept of a minimal period of value stability for individual action, there is no proof that it must exist. However, it is intuitively obvious that even the individual must have an expected value interval that is longer than zero for any choices which are more than just trivial.

For interpersonal choice we can do better, and prove the existence of value certainty over a minimal positive interval. This calls for the assumption that there is some minimal set of actions that each societal unit – group, organization, community, or whole society – must perform to ensure its continued existence or autonomy from other units constituting its environment. If we call T_a , the minimum period of effect of this set of actions, and $T_0 < T_a$, then T_0 implies a time horizon so short and a degree of adaptation so high that the unit ceases to be distinguishable from its environment as a separate system. Such a merger of all societal units would be a state analogous to the physical condition of entropy.

To the degree, then, that we are removed from such a condition of social entropy, there is a limit to value uncertainty:

$$\begin{aligned} \lim T_{vt} &= T_a \\ T_{vt} &\rightarrow T_0 \end{aligned}$$

To illustrate this in the form of a metaphor we may liken values in an environment of change to a savings account in an inflationary economy. The values generate 'interest' in the form of actions, and the degree of uncertainty may be equated with the rate of inflation. Then, if:

$$\begin{aligned} p &= \text{period of deposit } (= T_{vt}) \\ i &= \text{interest rate } (= T_a) \\ r &= \text{rate of inflation } (= \text{uncertainty}) \end{aligned}$$

$$\frac{dp}{di} > 0 \quad \frac{dr}{dp} < 0 \quad \lim_{r \rightarrow \infty} p = 0$$

But, if $i > 0, p > 0$.

In other words, the existence of any deliberate action in a social context, however changing, demonstrates that there are limits to value uncertainty.

The normative implication for organization theory of the above deduction must be that if a societal unit is coping with uncertainty by maximizing its adaptivity it must make a stand at a point which still maintains its essential autonomy. It is for the policy-maker operating under such a strategy to identify those residual decisions which bear on the essential existence of the organization itself. These may sometimes remain unrecognized in the light of the tasks to which the organization appears to be addressed, but are – by definition – crucial for its survival.

University of Wisconsin, Milwaukee

ERNEST R. ALEXANDER

NOTES

* This note was stimulated by a dialogue with Robert P. Biller, who should share credit for its ideas, but not any blame for its flaws.

¹ The metaphor of social and organizational 'Darwinism' is developed by Dunn (1971, pp. 111–112, 135–136) and in Terreberry (1968, p. 612).

² Tenbruck (1972, p. 32) uses a similar argument to relate the possibility of goal

achievement and the instability of preference structures, and thus to derive maximum and minimum planning horizons.

BIBLIOGRAPHY

- Alexander, Ernest R., 1972, 'Choice in a Changing World', *Policy Sciences* III, 3 325-337.
- Arrow, Kenneth J., 1964, *Social Choice and Individual Values* (2nd edition; Cowles Foundation Monograph, No. 12) Wiley, New York.
- Arrow, Kenneth J. and Hurwicz, Leonid, 1972, 'An Optimality Criterion for Decision Making Under Ignorance', in *Uncertainty and Expectations in Economics: Essays in Honor of G. L. S. Shackle* (ed. by C. F. Carter and J. F. Ford Oxford), Basil Blackwell, pp. 1-11.
- Billar, Robert P., 1971, 'Some Implications of Adaptation Capacity for Organizational and Political Development', in *Toward A New Public Administration: The Minnowbrook Perspective* (ed. by Frank Marini), Chandler, Scranton Penn., pp. 93-121.
- Dunn, Edgar S., 1971, *Economic and Social Development: A Process of Social Learning*, Johns Hopkins Press, Baltimore, Md.
- Emery, F. E. and Trist, E. L., 1965, 'The Causal Texture of Organizational Environments', *Human Relations* XVIII, 1, 21-32.
- Fishburn, Peter C., 1972, *Mathematics of Decision Theory*, Mouton, The Hague.
- Fishburn, Peter C., 1973, *The Theory of Social Choice*, Princeton University Press, Princeton, N.J.
- Friedmann, John, 1971, 'The Future of Comprehensive Urban Planning: A Critique', *Public Administration Review* XXXI, 3, 315-334.
- Friedmann, John, 1973, *Retracking America: A Theory of Transactive Planning*, Anchor Press/Doubleday, New York.
- Leinfellner, Werner, 1968, 'Generalization of Classical Decision Theory', in *Risk and Uncertainty: Proceedings of a Conference held by the International Economic Association* (ed. by Karl Borch and Jan Mossin), Macmillan, London, pp. 196-210.
- Mack, Ruth P., 1972, *Planning on Uncertainty*, Wiley-Interscience, New York.
- Marschak, Jacob, 1954, 'Toward a Preference Scale for Decision-Making', in *Readings in Game Theory and Political Behavior* (ed. by Martin Shubik), Doubleday, Garden City, N.Y., pp. 22-32.
- Marschak, Jacob, 1968, 'Decision Making: Economic Aspects', in *International Encyclopedia of the Social Sciences* IV (ed. by David S. Shills), Macmillan, New York, pp. 42-55.
- McWhinney, William H., 1968, 'Organizational Form, Decision Modalities and the Environment', *Human Relations* XXI, 3, 269-281.
- Menges, G., 1968 'On Some Open Questions in Statistical Decision Theory', in Borch and Mossin (eds.) *op. cit.*, pp. 140-154.
- Peston, Maurice H., 1967, 'Changing Utility Functions', in *Essays in Mathematical Economics: In Honor of Oskar Morgenstern* (ed. by Martin Shubik), Princeton University Press, Princeton, N.J., pp. 233-236.
- Shackle, G. L. S., 1969, *Decision, Order and Time in Human Affairs*, (2nd edition), Cambridge University Press, Cambridge.
- Shapley, Lloyd S. and Shubik, Martin, 1971, *Game Theory in Economics*, Rand Corporation, Santa Monica, Ca. (R-904/1-NSF).

- Tenbruck, Friedrich H., 1972, *Zur Kritik der Planenden Vernunft* ('Toward a Critique of Planning Reason'), Verlag K. Alber, Freiburg.
- Terreberry, Shirley, 1968, 'The Evolution of Organizational Environments', *Administrative Science Quarterly* XII, 4, 590-613.
- Thompson, James D., 1967, *Organizations in Action*, McGraw-Hill, New York.
- von Wright, G. H., 1972, 'The Logic of Preference Reconsidered', *Theory and Decision* III, 2, 140-164.