

## Fuzzy Logic as a Paradigm for a Mainstream Economics beyond Self-Sufficiency?

Peter Stolz\*

### I.

In economics, as in every other social science, value judgements with respect to method are inevitable. One such judgement is that neoclassical rational-choice models are powerful but need complementary perspectives. Every mainstream also depends on its tributaries. I wish to show that an economic behavioural model that is open to heterodox approaches can be fruitful in cases where phenomena are fuzzy instead of crisp.

Traditionally, formal - but implicitly also verbal - economic models use classical mathematics based on binary logic. Within this formal framework, an element either belongs to a certain set or it does not. There is no third possibility. But the absence of a blurred association of an element with a set can cause a paradox, for instance the one shown by Wang. «If a number  $x$  is small, then  $x+1$  is also small. If  $x+1$  is small, then  $x+1+1$  is small too. Therefore, five trillion is a small number, and so is infinity.» (McNeill and Freiberger 1993, p. 27). The «solution» offered by traditional set theory is to choose an arbitrary but sharp border between small and big numbers.

In 1965, L. Zadeh introduced the concept of a «fuzzy set» (Bronstein et al. 1995, p. 257) which contrasts with the traditional sharp set. Fuzziness is not vagueness in a stochastic sense. Rather it implies blurred boundaries of sets (Zimmermann 1992, p. 3) and is therefore a *deterministic* concept. Metaphorically spoken, there is every shade of grey between black and white. An element  $x$  can belong to a fuzzy set  $A$  to a degree  $\mu_A$  of say 0.6, where generally

$$0 \leq \mu_A \leq 1.$$

Intrinsic fuzziness is distinguished from informational fuzziness. *Intrinsically* vague, on the one hand, is a notion like «fair price» or «high cost»; it depends on subjective perceptions and feelings. *Informationally* fuzzy, on the other hand, is an attribute of a complex reality like «creditworthy customers» (Zimmermann 1992, pp. 4-5, 361-367). The more we deal in economics with variables beyond prices and quantities, the more the complexity increases and «our ability to make precise and yet significant statements ... diminishes» (Zadeh, cited by Zimmermann 1992, p. 3). But this trade-off between precision and relevance does not justify vague thinking about vague phenomena. Fuzzy logic makes it feasible to think precisely about blurred phenomena.

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\* Associate Professor, Wirtschaftswissenschaftliches Zentrum, Universität Basel, P.O. Box, CH-4003 Basel, Switzerland. This article was written in 1997 and is published here for the first time. The author is indebted to his colleague Prof. George Sheldon for improvements of the English.

## II.

Many phenomena in economic life and in economics are fuzzy, but they have been, or still are treated as if they were crisp. Although my focus in the present context is on the attitude of economists, I first give an example of real-world actors thinking in sharp sets where the idea of varying degrees of membership in fuzzy sets would be more adequate. Suppose that demand for a certain book is very inelastic between 30.00 and 39.95 Swiss francs whereas the difference between 39.95 and 40.00 francs is perceived as if it were a big «jump» in numbers. This perceived threshold (Streissler and Streissler 1966, pp. 75 and 82, n. 120) leads to a similar threshold in the price elasticity of demand. The quantity demanded decreases considerably when the book's price is 40.00 instead of 39.95 francs.

In demand theory and welfare economics, utility is an important but fuzzy notion (cf. McNeill and Freiberger 1993, p. 42). Originally this concept was treated as if consumers could express their individual utility in numbers. But theory has accomplished the change from an untenable idea of (crisp) cardinal utility to (fuzzy) ordinal utility. Irving Fisher (1867-1947) and above all Vilfredo Pareto (1848-1923) are prominent names in this context. Here is a good example where mainstream economics accepted fuzziness - certainly not to its own detriment: The main statements of demand theory stay intact, when merely a consistent ranking of utilities is presupposed and where utilities are only determined up to a monotonic transformation (Niehans 1990, p. 263-264; Monissen 1989, p. 219).

Blaug (1985, p. 330) emphasizes correctly that, formally, the law of diminishing marginal utilities implies a cardinally measured utility function  $U(q)$  with  $U \equiv$  utility and  $q \equiv$  quantity of the good consumed. With only ordinally defined utility, statements about  $d^2U/dq^2$  have no meaning. We only know whether  $dU/dq$  is positive or negative, but the direction (sign) of a change of marginal utility is unknown. Yet in indifference curves that are convex to the origin, diminishing marginal utilities are of course implied without using cardinal utilities. Let's observe real economic life and use «introspection» as an informal but legitimate method (McCloskey 1986, pp. 44-45). We experience satiation for instance in consuming a cake. In a certain time interval we enjoy the first piece as excellent, the second one as tolerably good, and so on until we are nauseous. We experience marginal utility as an ordinal concept, and because our perception begins with the first differences (not the utility itself), we as actors in real life can say that they decrease with growing consumption of the same good. If we as economists are «sharp and perceptive observers» (Harberger 1993, p. 15) we have to admit the existence of an empirical invariance of behaviour, a kind of «law of satiation». We should not apply too precise a model to a complex reality. What is impossible in a formal framework with ordinally defined utilities - the law of diminishing marginal utility - makes sense in the real world of our mind. The fuzziness of real life can clarify this paradox a little. Perhaps we should remember a passage of a letter which Alfred Marshall wrote to John Neville Keynes (Coase 1994, p.168): «...generally I never discuss any line of division or demarcation except to say that Nature has drawn no hard and fast lines, and that any lines Man draws are merely for the convenience of the occasion: and should never be treated as though they were rigid.»

### III.

But is introspection a reliable method? If one merely observes oneself, it is of course the smallest possible sample. Between individuals and between different economies and cultures, behaviour and patterns of behaviour may and indeed, do vary. But why should introspection be less reliable than assuming an artificial figure like the *homo oeconomicus* to explain behaviour, irrespective of differences between individuals, gender and cultures?

Economic man behaves in a way described by Max Weber with the term «Zweckrationalität», by which goals are ranked and instruments chosen with respect to the former. Weber made clear that by «Zweckrationalität» he meant a pure type and that behaviour in economic practice belongs to a greater or lesser degree to this type, being frequently blended with other behavioural forms such as certain intrinsic motivations (Weber 1956, p. 13). Again we find ourselves in the realm of fuzzy sets. Actual behaviour belongs to «Zweckrationalität» in a greater or lesser extent.

A rational choice-model in this fuzzy sense leaves room for intrinsic motivation. This is exactly the position of Bruno Frey (1992, p. 162) - to be sure without explicit reference to fuzzy logic: «The approach pursued stays within the rational choice framework on which economic theory is based, but psychological effects, disregarded in standard economics, are taken into consideration.» On the one hand, Frey bears in mind the fact that the boundaries of the sets of extrinsically and intrinsically motivated actions are fuzzy. On the other hand he considers additionally that intrinsic motivations may be «crowded out» by the intensification of extrinsic incentives - for instance effluent charges or even regulations in environmental policy. Nevertheless, one might ask whether, by using the price system in environmental policy, one could not economize on the *scarce resource* of cooperative behaviour (cf. Stolz 1987, p. 161) for use in other fields - for instance in social policy.

Intrinsic motivations are not merely an invention by scholars beyond mainstream economics. Controlled and real-world experiments have called into question the strong free-rider hypothesis in favour of a milder version (Dawes and Thaler 1988, p. 196; Pommerehne et al. 1994, pp. 505-506). One can conceive of free-riding behaviour as a fuzzy set. These results are not only important for public finance but also for development economics.

### IV.

Fukuyama (1995, pp. 29-39) argues in his book about the role of culture (in the sense of informal norms and institutions) in the development of nations that the neoclassical model is 80% true - undoubtedly very much for a social science, but not enough for an - often practiced - self-sufficiency of mainstream economics. The remaining 20% - the numbers must be taken as symbolic - have to be imported from other academic fields like psychology, sociology and history. With these numbers Fukuyama accepts that the rational-choice approach of neoclassical economics in fact *is* a powerful method, but needs complementary instruments.

Fukuyama's concrete message aims at the importance of trust in a network of informal norms and institutions. In an economy and society where there is a certain amount of trust beyond family, people less frequently have to resort to law; and transaction costs are all the lower, as a result. The (gradual) membership in a fuzzy set of economies with certain social virtues leads to consequences which can be cardinally measured (transactions costs). Intermediary organizations help to «produce» this social capital; where these groups are weak and trust is almost totally based on family, markets tend to be dominated by criminal gangs (Fukuyama 1995, p. 129) - to the extent that the state does not take vigorous action. Groups which fill the no-man's-land between family and state promote trustful relations among non-relatives and therefore enhance efficiency. Yet certain intermediary organizations are rent-seeking and endanger efficiency - all the more so the older the society and the tighter the network is knit (Olson 1982).

This dilemma was solved differently in Japan than, say, in Western Europe. Japanese behaviour belongs to a lesser degree to the fuzzy sets of free-riding behaviour and rent-seeking. In Japan, lifetime employment in big corporations, seniority payment schemes and Confucian, consent-oriented decision-making in private enterprises have led - until now - to economic success (Fukuyama 1995, pp. 198-249). In Western Europe and especially in Switzerland these patterns belong to public decision-making and could not be applied in pure form in private firms. We must not ignore the intrinsic motivations of producers and consumers in Western societies. But the higher extent of cooperative behaviour in Japan is to an important degree a consequence of a different history (Morishima 1982). And that is a parameter we cannot influence in the short or even medium run! What we can do is to apply our mainstream models carefully and to recommend neoclassical policies cautiously - avoiding the exclusion of the intrinsic motivations that are scarcer in Western societies than for instance in Japan.

## V.

The practical applications of fuzzy logic for the present belong more to business administration (e.g. Buscher and Roland 1993; Zimmermann 1992, ch. 14) and engineering than to economics. But I hope to have shown that the perspective is fruitful in the latter field, too. I might add that there is a further area where the perspective of fuzziness could enhance our understanding of the development of real economies as a whole. The concept of evolution has gained a certain attention in economics. Institutional change and technical innovations, which are prominent themes in this approach, could perhaps profit by the idea of fuzzy sets. I am uncertain whether the survival of evolutionary economics within our discipline can be taken as given. But should it survive and should the biological analogy make sense at all, fuzzy logic cannot be forgone: «...most biologists today recognize not only the fuzziness of species ... but also that this fuzziness is a key to evolution.» (McNeill and Freiberger 1993, p. 64).

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