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KEYNES ON PROBABILITY AND UNCERTAINTY

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Probability, Decision-making and Economics

Keynes was a student of probability before he became an economist. His Treatise on Probability was published in 1921, after Keynes had already established himself as a respected economist. This work, however, was based on a study prepared more than twelve years earlier as a prize fellowship dissertation for King's College, Cambridge (Moggridge, 1976, pp. 14/5). In that period Keynes divided his time between his activities at the India Office (1) and the study of probability. Harrod reported in his biography of Keynes that, according to one of Keynes's contemporaries, C.R. Fay, when Fay and Keynes "discussed the great question of one's future, it never crossed his mind that Maynard would become a professional economist. He assumed that, were Maynard to return to academic life, it would be as a philosopher. In writing to Pigou in the following winter (1903), Maynard said that, should he return to Cambridge,his field of study would be Logic and Statistical Theory."(Harrod, 1972, p. 147).

Whatever could be Keynes's plans then, his work on probability fits very well as the starting point for his ideas in his later development as an economist. Keynes approached probability searching for criteria to support practical decisions. Under some conditions one could devise rational methods of decision whereby a choice would be made of a sequel, that could be shown to be a "logical consequence" of a given proposition or premisses. In many cases,however,

neither certainty nor impossibility could be obtained by logic alone. In these cases the relation between premisses and sequel were said to be probable. Partial belief had to be then substituted for certain belief. According to Braithwaite "The originality of Keynes's approach lay in his insistence that probability, in its fundamental sense, is a logical relation holding between propositions that is similar to, although weaker than, that of logical consequence." (Braithwaite, 1973, p. XVI).

According to Braitwaite "Keynes's main motive in writing the Treatise was to explain how a degree of belief could be rational, and thus not merely a matter of the believer's psychological make-up but one which all rational men under similar circunstances would share." (id. p. XXI).

These 'statements of intention' show very clearly that a study of probability had to have important implications for Economic Theory, in particular for the brand of economics developed in Great Britain. Kregel has shown that the concern with actual decision-making processes taking place in the real world had been at the center of the stage of British neoclassical theory since its inception (Kregel,1977). Expectations and uncertainty in a historical (unidirectional) time setting "played a major part in the English neo-classical theory of value as well as in the theory of the cycle"(Kregel, 1977, p. 496). In contrast to the approaches most characteristic of continental European economics, that emphasizes systemic forces that impose themselves whatever

the expectations and decisions of individuals may be, British economics has been specially concerned with the making of decisions, and with the consequences that follow from the decisions" (Hicks, 1979, p. 5.). (2)

If economics is defined as a behavioral science centered around decisions, the process of decision-making has to fulfill two conditions. It has to be creative (or "uncaused" in Shackle's terminology). (3) This means that to make decisions is not just to react in an automatic fashion to ongoing stimuli. To decide cannot be reducible to mere adaptation, which means that one cannot link directiy environmental conditions to behavioral results. One is not denying the existence of systemic requirements, of natural and social laws or of any other outside influence on the decision-maker. These are seen, however, as pieces of information for, not of command over, the process of decision. As Penrose aptly put it in her discussion of entrepreneurial strategies, "it is not the environment 'as such', but rather the environment as the entrepreneur sees it, that is relevant for his actions." (Penrose, 1980, p. 215). Of course,"whether experience confirms expectations is another story" (id. p.5).

A second requirement is that the process itself through which decisions are reached may be analysed into consistent and logically connected steps. There must be a criterion of decision and a method of constructing the sequels of a set of premisses to inform the decision.

Decisions are made with reference to the sequels each choice is believed to generate. Rational choice is the one which maximizes the possibility of obtaining the most desired sequel. Application of reason means then the search for the alternative in which the desired sequel can be shown to result most directly, given the perceived or expected constraints, from the choice to be made. This judgement can only be made if the decision-maker can show how each step follows its antecedent and shapes the next in the chain connecting the decision to the expected outcome.(4) If the construction of sequels obeys the rules of Logic it will be independent of the "believer's psychological make-up" and it will be possible to study it scientifically.

When a decision is made, thus, a given sequel is chosen through which the premisses, the description of the starting point of the decision-maker, are connected to the aimed outcome. A process of choice could then be seen as being constituted by two elements: the initial data and the reasoning process leading to the outcomes.

The second of those elements, the construction of the relation between starting propositions and final outcomes, is the central subject of Keynes's Treatise on Probability. The ultimate goal is to find the laws of rational decision-making to serve as foundations of behavioral sciences, including economics. As Keynes put it, "between two sets of propositions... there exists a relation, in virtue of which, if we know the first, we can attach to the latter some degree

of rational belief. This relation is the subject-matter of the logic of probability." (Keynes, 1973, pp. 6/7). That choices of conduct is his ultimate concern is made clear by the statement that, for equally desirable outcomes,"we might put it ... that the probable is the hypothesis on which it is rational for us to act" (id. p. 339). The same concern in pervasive in the discussion of the inductive principle and the informational content of frequency studies.

Keynes versus Laplace on Probability

Nowadays, when one thinks of probability the ideas that most naturally come to mind are those proposed by the frequency theory, where "probability is a property of random experiments" (Hicks, 1979, p. 105). (5) Keynes, however, presented a fundamentally different view of probability. Probability, in Keynes's view, has to do with the method of deriving propositions from given data or from given assumptions. The theory of probability is concerned with the methods with which this derivation is obtained. The theory, thus, is part of epistemology. It does not deal with events or material processes as such but with propositions. As Keynes proposed in the opening lines of the Treatise: "Part of our knowledge we obtain direct; and part by argument. The Theory of Probability is concerned with that part which we obtain by argument, and it treats of the different degrees which the results so obtained are conclusive or inconclusive" (Keynes, 1973, p. 3). Most specifically, Keynes is concerned with determining the degree by which to

believe in a proposition resulting, by argument, from another is rational: "Probability is the study of the grounds which lead us to entertain a 'rational' preference for one belief over another" (id., p. 106, Keynes's emphasis).

For Keynes the theory of probability had to do with the method of relating two propositions. " Rational belief" refered to the logical plausibility of the derived proposition with respect to a given starting proposition.The extent to which the resulting idea is true knowledge depends on the truth of the starting point. In the Treatise on Probability Keynes does not deal with the latter. Rather,he simplifies the problem by supposing that the starting proposition is always obtained by direct knowledge. In an even bolder assumption, Keynes then proposes to consider direct knowledge true knowledge (id., ch. 2) (6).

Assuming that the starting proposition is true allows Keynes to concentrate on deriving knowledge by argument. The space of probability is defined then as the application of logic to propositions to obtain other propositions: "Given the body of direct knowledge which constitutes our ultimate premisses, this theory tells us what further rational beliefs, certain or a probable, can be derived by valid argument from our direct knowledge." (Keynes, 1973, p.4,my emphasis). Which arguments are valid can be logically ascertained. Belief in the conclusions is then rational because it does not depend on individual peculiarities but on criteria of consistency

with formal logic. The outcome,being a logical derivation of the premisses,shares the truthfulness of the latter.

The choice of the premisses is in any case the domain of the individual. Probability, however, is not concerned with the choice of premisses but with their logical unfolding into conclusions: "[I]n the sense important to logic, probability is not subjective. It is not, that is to say, subject to human caprice. A proposition is not probable because we think it so. When once the facts are given which determine our knowledge, what is probable or improbable in these circumstances has been fixed objectively, and is independent of our opinion. ... What particular proposition we select as the premisses of our argument naturally depends on subjective factors peculiar to ourselves; but the relations, in which other propositions stand to these, and which entitle us to probable beliefs, are objective and logical" (Keynes, 1973, p. 4).

Probability, then, is approached by Keynes as part of the process of learning. The larger the body of knowledge gathered as premisses the more complete and certain the conclusions obtained by argument can be. In the limit, we can imagine a set of premisses that is sufficient to logically imply a certain result. In this case, probable belief becomes certain belief. But direct knowledge may not be capable of generating a sufficient set of true premisses to sustain an outcome with certainty. In some cases direct acquaintance may be downright impossible (e.g., in sequential processes

some premisses may refer to events that can only be contemplated in the future). In this case the logic of reasoning cannot substitute for the insufficiency of knowledge to obtain certain outcomes.

The accumulation of premisses changes the probabilities of results but these cannot be compared because each one of these refers to a different body of knowledge. Probability in Keynes's sense is usually non-quantifiable, although in some cases at least ordinality is possible (Cf. Keynes,1973, ch. 3).

Keynes's view of probability is to be contrasted with the dominant view about the concept. As noted above, this place is occupied by the frequency theory.

The most important contrast between Keynes's approach to probability and the frequency theory is the very definition of the object of study. For the frequency theory, probability is a relation between events, a characteristic of the world itself (7). The accumulation of knowledge does not change probabilities, because randomness is a feature of the object of knowledge, not of knowledge itself. The theory of probability, thus, consists in the accurate description of the forms this randomness may assume, and their properties.

In this context, Bernoulli's theorem (8) is both a method of discovering the true character of random processes

and a basis for the inductive principle, supporting the law of large numbers. Probable results are comparable and probabilities are quantifiable. If the stochastic processes are stable enough, repeated observation leads to the knowledge of their underlying structures.

The frequency theory rests on assumptions much stronger than Keynes's, even if we ignore the difficulty of explaining randomness as a feature of real processes.While Keynes had only to assume the truth of premisses in order to concentrate in how to obtain logical conclusions from them, frequency theory has to assume the reality of its premisses. Keynes's theory is about rational decision-making. Frequency theory is about actual states of the world. While Keynes is concerned with mind processes, frequency theory works with nature itself. Keynes's theory can be easily extended to deal with (unquantifiable) uncertainty. For frequency theory "there is no such thing as an unkown possible outcome - one that cannot be identified because it has not yet been seen or is unable to be contemplated" (Katzner,1986, p. 60).

In sum, while for Keynes each probable relation is an individual by itself, with frequency theory probability can only be ascribed to a particular relation as part of a larger family of individual observations. It distributes certainty among events. It is the whole distribution function that matters. An isolated statement of a probability relation is basically meaningless. As a result, "regardless of whether

one interprets [probability] as frequency, logical or subjective probability the notion of repeated questioning is, in one way or another, always present." In addition, "the probabilistic laws governing the answers to the original question are known in their entirety. There is no uncertainty or ambiguity of meaning in the statement that event A has probability p(A)" (ibid.).

Shackle has repeatedly emphasized that probability is knowledge while uncertainty is unknowledge. Frequency theory is doubtless a form of knowledge. The peculiarity is in the object itself not in its perception. Frequency theory is knowledge of stochastic processes. Keynes's probability, however, is not knowledge in the same sense. The truth of premisses is an assumption, not an axiom. As Shackle has written, even under uncertainty "we are not hopelessly ignorant, for we can set bounds to what can happen" (Shackle, 1966, p. 134). To bound uncertainty is to eliminate expectedly impossible sequels in the decision process. Impossibility is expected when some outcome cannot be shown to logically follow from a given set of premisses. Keynes's Treatise on Probability was dedicated to the connections between premisses and expected outcomes. To deal with uncertainty we have to deal with the premisses themselves.

As a matter of fact, the development of Keynes's ideas on decision-making gradually changed from the focus on probability to focusing on uncertainty. This change, however, did not require any important change in his basic views. It

followed from his increasing attention to the premisses of decision, shifting from the assumption of true knowledge gained by direct observation to expectations and the fragility of the information on which they are anchored. Once this was accomplished, only unimportant changes, if any, were necessary as to his ideas on logical methods of argumenting.

Uncertainty and Probability

In the Treatise on Probability Keynes had presented the problem of determination of probabilities as being the same as determining the degrees of rational belief in a relation between propositions. As it is well known, this view was criticized by Ramsey who proposed that while probability was a question of formal logic, belief, even if rational belief, was a question of human logic, those "mental habits" that are "also a sort of logic" (Keynes, 1951, p. 243). Keynes conceded the point, although still unsure of its implications.(9)

The question centered around induction and the derivation of rules of conduct. Is a given behavior determined just by a certain amount of evidence as premisses and its logial developments?

Keynes had met this question for the first time in the Treatise when he introduced a discussion of the "weight" of arguments. The weight of an argument is not determined by a comparison "between the favourable and unfavourable evidence, but between the absolute amounts of relevant knowledge and of relevant ignorance respectively" (Keynes, 1973, p.77), This

kind of evidence does not reveal any new logical link between the propositions, nor denies any other. It just corroborates or repeats some already known argument (in a positive or a negative sense). In these conditions, this new evidence may not change a probability but it alters its "degree of belief".(10) The degree of belief on a probable relation depends on how strong the signs are that relation is not only probable but actually true. This is the field of "human logic". It did not find a place, however, in the Treatise on Probability. Keynes conceded in the opening lines of his discussion of the subject that "the question to be raised in this chapter is somewhat novel; after much consideration I remain uncertain as to how much importance to attach to it" (Keynes, 1973, p. 77). Concerned with logical connections alone, Keynes will evade the point by keeping it isolated from the rest of the Treatise. The weight of arguments was to be revived only much later, when Keynes's approach to uncertainty was much better developed, in the discussion of states of confidence in The General Theory.

How could confidence (or belief) be introduced in Keynes's theory of probability? Certainly not in the method of construction of sequels. If one wants to preserve the rationality of methods of decision reasoning has to develop along logical paths. If this is accomplished through the use of formal logic the sequel has to be contained somehow in the premisses themselves. If the set of premisses is "complete" the sequel is entirely determined. Formal logic does not "create" sequels, it can only reveal whatever is already

implicit in the premisses.

But what if the premisses are not complete? Then the decision-maker has to fill the voids, has to "create" the additional premisses may be needed in order to apply logical methods to them. If this is the case, the starting proposition, even if it is true knowledge, is not sufficient to logically imply some other proposition. Actually, logical processes cannot even be applied until the missing premisses are somehow included. In situations of this nature, some of the premisses may represent true knowledge but some of them will be just hypotheses. These hypotheses may themselves be probable relations but they may also be "figments of imagination", to use again Shackle's terminology.

We can see that the point turns around the determination of premisses in causal processes. Hicks has proposed to distinguish two kinds of causal relation between propositions(11). Strong causation is a relation where A is the cause of B. Weak causation happens when A is one cause of B (Hicks, 1979, ch.2). In presence of strong causation, we may say that A logically implies B, so the relation between both is of certainty. In this case, if A is observed, we know B will follow. Under weak causation, the relation between A and B is probable but not necessarily certain. If we cannot observe the complementary premisses (causes) and we observe A we can only form expectations about whether B is to follow by forming hypotheses about the additional premisses.

Uncertainty may emerge in relations of weak causation when, for some reason, the knowledge of the additional causes of an expected outcome is lacking. The set of premisses is then not sufficient to establish certainty and the agent has to "create" the additional premisses needed to build a sequel. In this sense we can say, following Shackle, that the agent does not choose from a given list of possibilities, he actually has to create the list. This is the main distinction between the Keynes/Shackle theory of choice and the mechanistic models of choice. In a remarkably elegant passage Shackle presented the whole point: "The imagined sequels and their claim to possibility must consult reason at every step; every constructed ambition must use reason as the indispensable sanction and the condition imposed by practical conscience. Reason, however, is the fitting together of ideas. The strong temptation of a theory of determinate conduct is to suppose, without argument, that the ideas which reason fits together are in some way 'given'. Conduct, this view assumes, is the fitting together of a jigsaw puzzle. The pattern in which this can be done is unique, determined by the shape of the pieces. ... We have elected, by contrast, to suppose that the shapes of the pieces are originated by the chooser. When the chooser has imagined them, reason still dictates that they be fitted together. Non-determinism is as much the employer of reason as determinism. It recognizes, however, the question: whence are the ideas that we reason about?" (Shackle, 1979, pp.56/7).

In the Keynes/Shackle concept of uncertainty not only some premisses may be unknown at the moment of decision

but they may actually be unknowable. This is easily perceived when we think of decisions such as production or investment decisions. The entrepreneur has to form expectations about other entrepreneurs' conduct as well as about his customers'. His competitors are, naturally, compelled to do the same. In this way it is logically impossible to include these conducts as premisses alongside with the premisses he does know, such as the amount and technical efficiency of his equipment, the contractual obligations of workers and suppliers, etc. The missing premisses just do not exist. They have to be created by the decision-maker in order to build a sequel but they are not "knowledge". Rather, as Shackle put it, they are "unknowledge".

When we think of sequential, real-world economies, the number of unknowables of that kind is much increased. Now at each step the decision-maker has to fill new voids and create new premisses in increasingly complex algorithms and a growing number of possible sequels. Uncertainty means the acknowledgement of the impossibility of dealing logically with this complexity. (12)

Uncertainty thus in the process of decision-making is a result of acknowledging the extent to which ignorance leads to imagination substituting for knowledge as the basis to choose premisses. Formal logic can only sustain robust expectations if we <u>assume</u> the premisses to be correct. When we know the premisses to be no more than figments of imagination, human logic comes to the fore, the weight of

arguments becomes relevant and uncertainty finds its place alongside probability in Keynes's sense.

This is precisely the way Keynes introduced the uncertainty that surrounds investment decisions in The General Theory: "The outstanding fact is the extreme precariousness of the basis of knowledge on which our estimates of prospective yield have to be made. Our knowledge of the factors which will govern the yield of an investment some years hence is usually very slight and often negligible" (Keynes, 1964, p.149). This is typically a case where the premisses on which to build a probable relation cannot be based on knowledge, specially on direct acquaintance. Nevertheless, a decision has to be made. However "flimsy" may be the foundations for this decision, the entrepreneur has to gather whatever knowledge he could accumulate (e.g., in terms of current technologies, current financial conditions, demand elasticities, etc.) and to create premisses in terms of how his customers will behave, how his competitors will behave, future technological changes, changes in relative prices, and so on. Given these premisses, a probable relation can be built. The uncertainty pertains to the premisses and from them it spreads to the outcomes.

Human logic and the role of the weight of arguments reappear in his context as the degree of confidence, or the state of confidence. The equivalence of concepts is pointed by Keynes himself when he observed that "It would be foolish, in forming our expectations, to attach great weight to matters which are very uncertain". At this point Keynes

introduced a footnote saying: "By 'very uncertain' I do not mean the same thing as 'very improbable'. Cf. my Treatise on Probability, chap. 6, on 'The Weight of Arguments'". (Keynes, 1964, p. 148).

Rational belief, when the decision process now can no longer be established in terms of true premisses, cannot attach to expected outcomes only on the basis of a logical development of those premisses. Rational belief will also have to depend on the confidence on the premisses themselves. As Keynes proposed, the confidence will depend "on how higly we rate the likelihood of our best forecast turning out quite wrong" (ibid.). If we assume that the agent will handle adequately formal logic methods that likelihood cannot only depend on the accuracy of the premisses.

Uncertainty and probability, taken in Keynes's sense, are thus complementary concepts, the former related to the choice of premisses, the latter to the logical development of them. That is why "very uncertain" is not "very unprobable".

Uncertainty and Ergodicity

We could, of course, conceive conditions where the creation of the missing premisses was rather an objective process of "discovery". If social processes were ergodic (Cf. Davidson, 1986) trial and error could lead agents to gradually identify all the necessary data to orient their decisions. Ergodicity, however, demands replicability, which

means that processes should be time-independent. It cannot survive a world where a "crucial decision" is possible because the latter destroys the environment in which it was taken. Replicability, even notional replicability, does not make sense for "crucial experiments", In a Keynesian world, a non-ergodic world, there are no inevitable, pre-defined paths to the economy. Agents have to create by themselves their own images of sequels and act on them. As a result, history will result from the fusion of men's actions, in a way that is not really predictable to anyone of them nor even to an external observer. If innovations are a theoretical possibility, ergodicity cannot be sustained.

Uncertainty, therefore, is not a result of defective methods of reasoning. The insufficiency of premisses is rooted in objective features of actual social processes. The lack of knowledge about, for instance, future demands of goods to serve as premisses to an investment decision in a monetary economy cannot be overcome by observation or by developing better means of information. As Kregel put it, there is a "crucial feature [in]a monetary economy that allow[s]consumers not to spend all their income, not to know what they would consume in the future, and to forestall decision over the expenditure of their income: a store of value that preserves the purchasing power of current income." (Kregel, 1980, p.39). Under these conditions, "no future market signal is given because there is nothing more to signal" (id., p.36). Uncertainty is the reflexion at the decision processes of these characteristics.

Probability, Uncertainty and Conduct

The central point is that Keynes's notions of probability and of uncertainty are actually connected. They spring from a "vision" of the world that is very different from the vision proposed by the frequency theory.

When the focus of discussion shifts towards the creation of premisses rather than the logical methods of derivation of conclusions the place of human logic or of the weight of arguments become crystal clear. They have to do not with deriving ideas but with conduct. The building of a sequel may have been perfectly logical but the agent knows that if his knowledge was incomplete, the premisses he created could be false. Acting on the basis of those probabilities may cost the agent something if the premisses actually reveal themselves to be false. That is where the state of confidence and concepts like "animal spirits" come in. The probability relation continues to be valid. Two rational agents with the same premisses will always find the same results. The extent to which they will act on them, however, will depend on each one's confidence on the validity of the added premisses.

The need to partially create the premisses on which to base decisions gives the agent the degree of freedom he lacks in deterministic worlds. But if the world admits the novelty it also displays continuities. Although in the strictest sense the world changes continually (13), for practical purposes there is enough continuity in social processes to

allow some space to the principle of induction. This certainly was Keynes's view not only in the Treatise on Probability but also in The General Theory.

The full validity of induction requires some stringent conditions that were examined by Keynes in detail (Keynes, 1973, chs. 18, 19 and 20). In particular, it requires enough repetitiveness to allow agents to learn from experience and also that the degree of complexity of the experience itself be not excessive lest agents will not understand the nature of the experiment and draw its lessons.

These requirements are obviously not fulfilled in the case of investment decisions. These decisions are crucial, non-repetitive and their sequels too complex to be generalized. Past experiences in the case of investment do not safely indicate the direction of the future. Production decisions, however, are seldom crucial. They do not imply irreversible commitments of resources and can be checked after very short intervals. Markets tend to be continuous for short periods so similar experiments can be realized and generalizations drawn. The missing premisses in the case of production decisions are not, under normal conditions, impossible to visualize with some assurance. For investment decisions, human logic dominates formal logic and induction is impossible. For production decisions, the premisses are safer, formal logic can dominate expectations formation and the possibility of induction preserved. (14)

One of the most important innovations of The General Theory was the distinction proposed between short-term expectations and long-term expectations. Incapacity to perceive this distinction led pre-Keynesian authors (including Keynes himself up to the Treatise on Money) to undue stress on induction to explain investments. These were related directly to current variables as if the latter were sufficient to support investment decisions. When the distinction between short and long term expectations (and of the nature of the decisions to which, they give rise) is established we gain a better understanding of the motives behind production and investment decisions, the role and effects of changes in the states of confidence and insights on the different degrees of instability associated to each behavior.

Concluding Note

In this paper we intended to show that there is a fundamental continuity in Keynes's views on probability and uncertainty. Although separated by more than two decades, the elaboration of his ideas on probability and the development of the concept of uncertainty in the thirties reflects different emphasis within a unified conception of the decision-making process. The initial emphasis was put in the logic relation between premisses and results, on the assumption that premisses were true. Keynes shifts his focus to the premisses themselves and to situations where they are incomplete to sustain a decision. The need to create premisses to fill the voids is the basis for uncertainty,

non-determinism and the importance of concepts such as the weight of arguments, or state of confidence, with which Keynes could not deal in the Treatise.

Keynes's notion of probability is closer to "unknowledge" than to knowledge, as it is the case with the Frequency Theory concept of probability. That is why Keynes's use of probability is not incompatible with uncertainty while the latter is.

To understand the relation between the human logic of the degrees of belief and formal logic of probability allows to better understand the dynamics of a monetary economy by differentiating the forces shaping production and investment decisions.

Notes

(1) - Where "there were frequent complaints of his having nothing to do during office hours", cf. Harrod, 1972, p. 142.

(2) - At this point it may be interesting to emphasize the point made by Kregel that "it would not be correct to view Keynes as a bold innovator in this regard, but rather as representing the culmination of a long tradition in which expectations and uncertainty had always played and integral part" (Kregel, 1977, p. 497). Some critics have repeatedly raised the point that Keynes, and post Keynesians for that matter, propose a nihilistic view of economics because the stress laid on individual decision-making under uncertainty would prevent the identification of those regularities necessary for science to exist. This misunderstanding of Keynes's proposals is discussed at length in Carvalho, 1986, and cannot be discussed here. The point, however, is that "the originality of Keynes (and Shackle) is then not the simple recognition and introduction into economics of the implications of uncertainty and expectations, but rather the much more significant recognition that the full implication of these aspects of real economies could not be handled adequately within the framework of traditional theory and thus required a completely new theoretical approach". (Kregel, 1977, p. 498).

(3) - The decision-maker "may assume that his act of choice is in some respects and absolute origination, something not wholly implicit in antecedents, he may deem his thoughts to be not entirely determinate, but able to come in part ex nihilo. If choice can be of this kind, I shall call such and act of choice an uncaused cause." (Shackle, 1983, p. 28).

(4) - "The imagined histories designed for filling time-to-come must seem to the chooser not impossible. But this adjudged capacity-to-be-realized has three separately indispensable bases. Any such history claiming a part in the business of choice is required to conform to Nature and human nature, it must respect the principles of the architecture of the field. Besides this, since 'time-to-come' takes its start from the chooser's present, a history for that time must be an evolution starting from the situation at that present, as the chooser sees it. ... The possibility of each such history must depend upon the chooser's making an appropriate choice of action. The histories must be looked on as sequels of action." Cf. Shackle, 1979,p.14/5.

(5) - As Hicks stresses, there are important conceptual difficulties involved in this definition: "What is meant by random? No one, to my knowledge, has given a definition of randon which does not refer back to some

form of the above definition of probability." Hicks adds in a footnote to this passage Cramer's statement that "It does not seem possible to give a precise definition of the word 'random'." (Hicks, 1979, p.106).

(6) - Keynes makes a rapid incursion in the field of the theory of knowledge in chapter 2. His intention seems to be to define his epistemological assumptions rather than discussing epistemology per se. In this chapter, Keynes proposed that direct acquaintance with things is the source of knowledge about them, "experience, understanding and perception being three forms of direct acquaintance" (p.12). The object of knowledge, comprehending sensations, meanings and perceptions, are then called 'propositions' (ibid). "About what kinds of things we are capable of knowing propositions directly, it is not easy to say." (p.14). Keynes argues that "we cannot know a proposition unless it is in fact true" (p.11). This sense of the term "knowledge" is however too strong and Keynes later opted for something weaker but closer to common sense: "To employ a common use of terms (though one inconsistent with the use adopted above), I have assumed that all direct knowledge is certain." (p.17) "I assume then that the only true propositions can be known" (p.18, my emphasis). As it will be proposed in the next section, uncertainty emerges when we focus on the starting propositions rather than in the method of argument.

(7) - As, for instance, in quantum mechanics.

(8) - For a statement of Bernoulli's theorem see Keynes, 1973, p. 370.

(9) - "So far I yield to Ramsey - I think he is right. But in attempting to distinguish "rational" degrees of belief from belief in general he was not yet, I think quite successful. ... Yet in attempting to distinguish a "human" logic from formal logic on the one hand and descriptive psychology on the other, Ramsey may have been pointing the way to the next field of study when formal logic has been put into good order and its highly limited scope properly defined." (Keynes, 1951, p.244).

(10) - "Weight cannot, then, be explained in terms of probability. An argument of high weight is not 'more likely to be right" than one of low weight; for the probabilities of these arguments only state relations between premiss and conclusion, and these relations are stated with equal accuracy in either case." Keynes, 1973, pp. 82/3.

(11) - Causality is seen as a relation whereby a proposition "explains" another. In this discussion, the proposition of a given outcome is shown to result, i.e., to be caused, by a starting proposition.

(12) - Keynes's famous passage in his 1937 "The General Theory of Employment" fits very well in this interpretation. Lotteries and roulettes do not demand the creation of

new premisses. However, the prospects of a war in Europe, the market for copper or the behavior of the rate of interest, "twenty years hence", demand the creation of premisses ex-nihilo. It is not a question of formal logic or of probability as he discussed in the Treatise. In this case, "we simply don't know". (Keynes, 1973b, pp.113/4). A similar posture, now related to international political affairs, is offered by Keynes when he writes that "I believe in living from hand to mouth in international affairs because the successive links in the causal nexus are so completely unpredictable" (Keynes, 1982, p.120).

(13) - Even the physical environment is changing if one accepts the law of entropy. Cf. Georgescu-Roegen, 1971.

(14) - These remarks have the somewhat paradoxical effect of suggesting that center of gravity concepts could end up being more appropriate to short rather than to long period analysis. This possibility was suggested by A. Asimakopulos in a debate at the First International Summer School, at Trieste, 1981.

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